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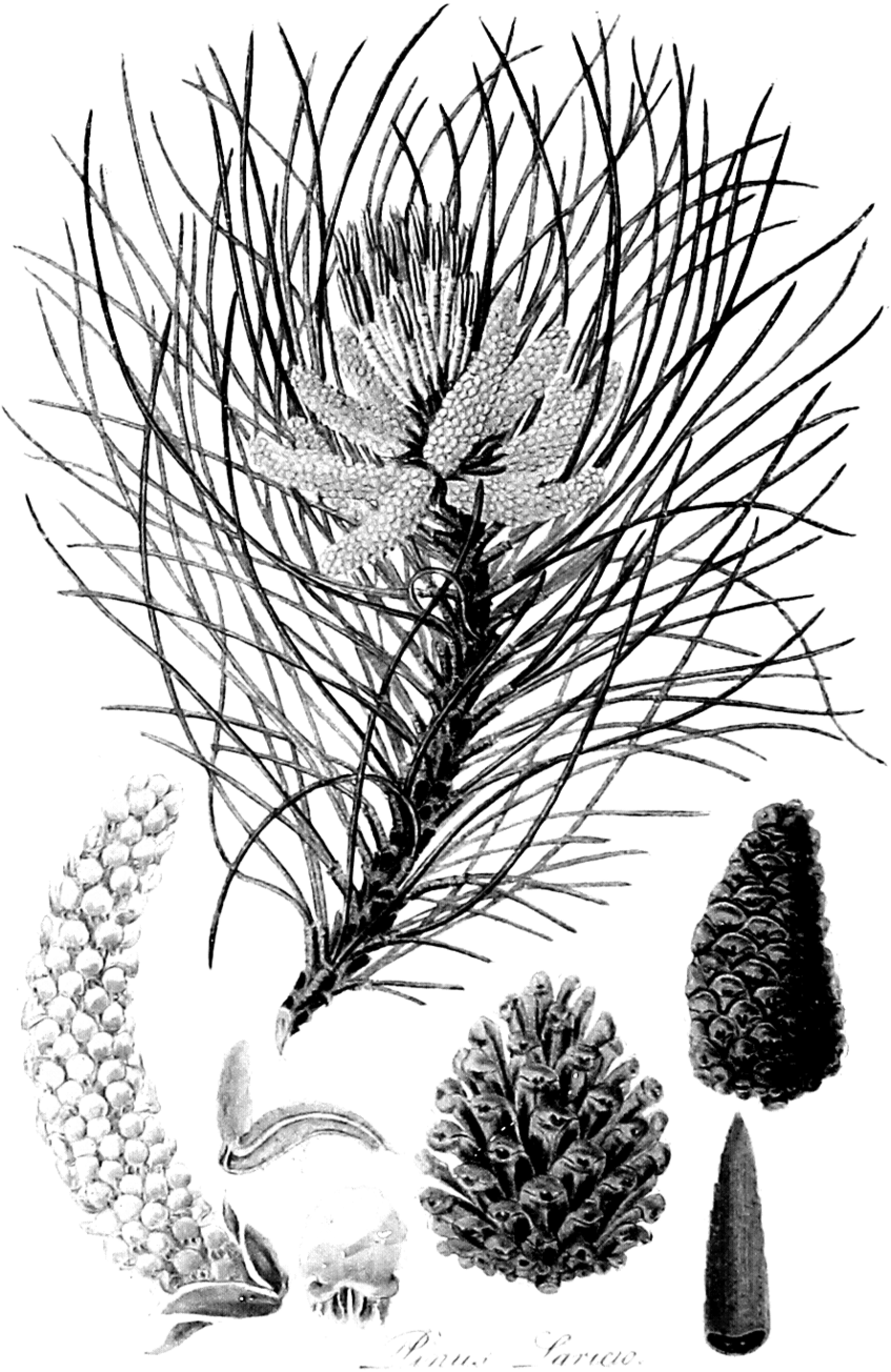
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I. THE CORSICAN PINE, SHOWING MALE FLOWERS IN MAY, WITH DETAILS OF STAMENS, CONES AND A LEAF TIP

FORESTRY AND WOODLAND LIFE

By H. L. EDLIN

B.Sc. Forestry, Edinburgh; Diploma in Forestry, Oxford

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* * *

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PREFACE

This book is planned as an outline for the layman, and as a summary for those concerned with forest work, of the science and craft of tending woodlands as at present practised in Britain. In order to understand how woods may be created and their growth controlled, it is necessary to know something of the background of natural history that influences them at every stage. To many people this is the most interesting aspect of forestry, for a forest is a living, growing, and breathing thing, and its wild life is as much a part of it as are the tall trees themselves.

The first eleven chapters are therefore devoted to the natural growth of trees, and the influence of soil, climate, and wild plants and creatures of all kinds upon the life of the forest. The woods are here regarded mainly as a natural phenomenon, without particular regard to their effects on human economy, or their need for human care. It is important to realise at the outset that forests can and do arise without man's aid, that they are in fact far older than man, who is but a child of the primeval woods.

The subsequent chapters take up the story of man's influence on the forest, starting with the earliest times when he moved through its depths as a hunter and trapper, and coming down to the development of systematic and scientific forest practice, theory, and management in recent centuries. The effects of forests and their products on different aspects of art, craftsmanship, and literature are considered in the penultimate chapter; whilst the varied beauties of the changing forest scene are suggested in the final pages.

The accounts of work in the forest, raising young trees, planting, tending, and felling plantations, are intended to make clear the normal course of events in the treatment of an average wood. Obviously the whole range of possible forest operations cannot be compressed into a single volume; and each item should, in any case, receive the careful consideration of a trained and experienced forester before the work is put in hand.

Similarly the descriptions of specialised aspects of scientific forestry and forest biology are but brief reviews of vast fields of research and study, on which many volumes have been written. But the aim here is not to add another textbook to the lengthening series, but rather to explain forestry as a whole in simple terms to all who study it for interest, as their main occupation, or on account of its importance to their work in other fields of science, administration, or commerce. A review of this kind may be of material help to those who intend to study forestry more deeply, since it aims to show how every aspect of it is interwoven and interdependent, and so may form a background to more specialised work.

Each subject has been dealt with from the standpoint of the British forester, and the descriptive matter and examples of forest work are drawn entirely from British sources. Although our scientific forestry owes a great deal to continental, and especially to German, origins, it is now reaching the stage when it may base its theories on the practice of its native land. Too many of the existing textbooks draw their inspiration from foreign methods which, however effective they may be abroad, have little practical application under the very different climate, rural economy, and general conditions of the British Isles. The undue attention paid to continental methods and theories has tended to create the impression that the craft of forestry is an alien importation without roots in our native soil. Such is not the case. Both Scottish and English foresters have developed the technique of their craft with but little outside aid, skilfully adapting it to meet local circumstances, and they may fairly take the credit for such success as has been achieved.

Everyone now sees something of the woodman's work, and has some indirect share in its success or failure. Two great wars have clearly shown our dependence on our own woodlands, which continues in times of peace. This outline of woodland life and forest work may show how natural forces and man's handiwork combine to raise and renew the great woods that enrich both the economy and the scenery of our countryside.

H. L. E.

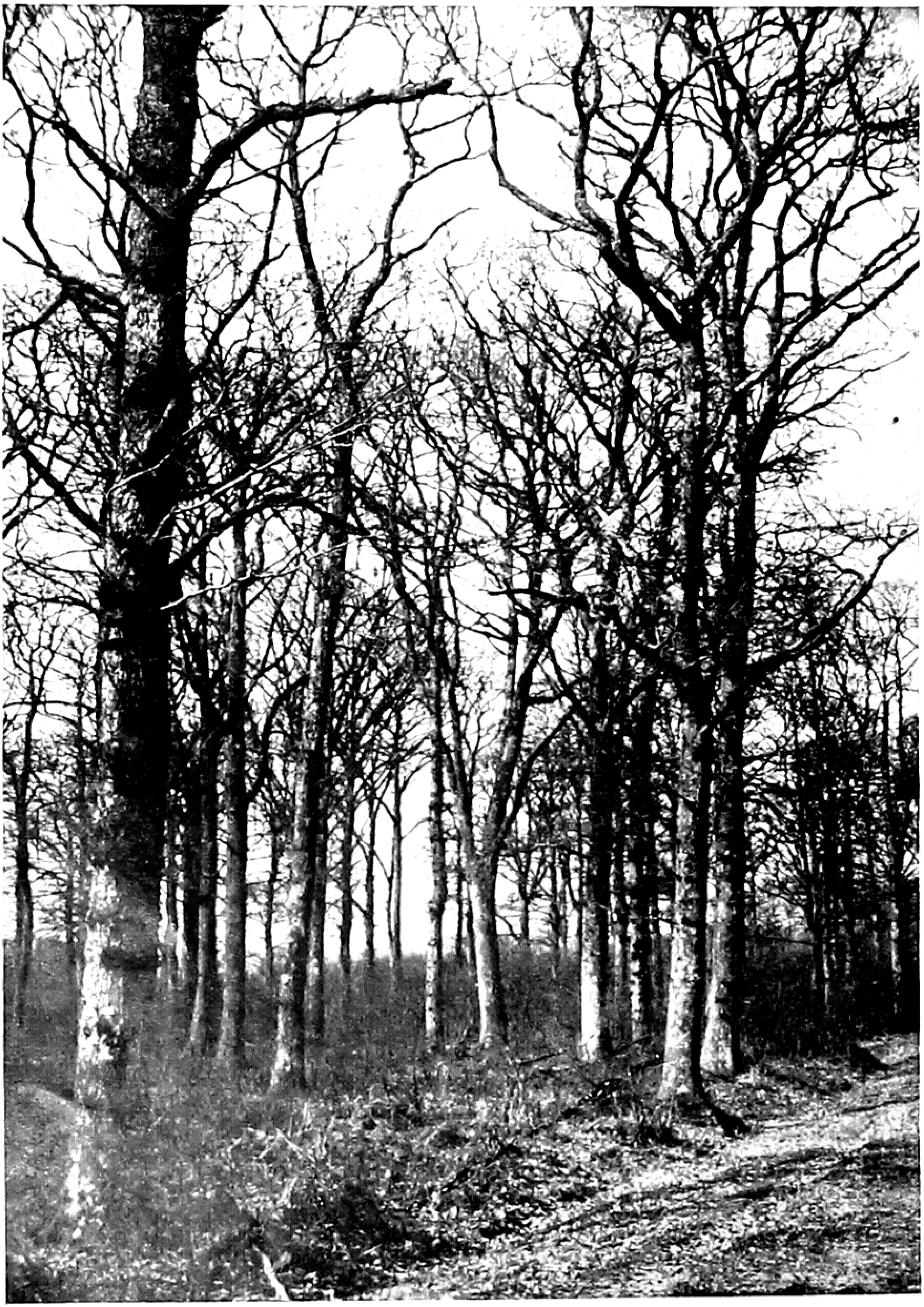
* * *

" Till from the breathing lawns a forest springs,
Of youth, integrity, and loveliness.
Its buds unfold more brightly till no more
Or frost or shower or change of seasons mars
The lustre of its cup of healing dew,
The freshness of its amaranthine leaves,
That fills the waste with hues of vital bloom.

Again deep groves wave in the wind, and flowers
Gleam in the dark fens of the tangled woods ;
And many a bird and many an insect keeps
Its dwelling in the shade, and man doth bend
His lonely steps to meet the angels there."

Shelley.

2 SILVER BIRCHES IN THE WIND



3 HIGH FOREST OAKS AT FERNHURST, WEST SUSSEX

CHAPTER I

THE WILDWOOD

The forest is one of the great natural types of vegetation that clothe the surface of the earth. It forms the highest development of plant life as a community. The tall forest trees make use of their environment to the full. They modify the local soil and climate, even at times the rocks themselves, and dominate the animal life that teems in their midst.

Forests occur naturally in all the regions of the world where rainfall, soil, and temperature permit their countless trees to thrive. Cold restricts their spread towards the poles and towards the summits of the highest peaks. Drought checks them in the zones of the desert and steppe, and in some areas the bareness of the rock denies the trees their roothold. But everywhere else forests, in one form or another, are found as a natural form of plant growth.

Mankind is younger than the forest. Indeed it is probable that man could only have arisen to his present stature in the forest or on its fringes. Wherever the forest extends, man has gone, sometimes as a hunter of wild animals or a gatherer of fruits, sometimes as a cultivator cutting clearings to grow his crops. In settled countries the impact of mankind upon the forest has been such that the trees have gone under. Thus, in Britain, only five per cent. of the land area remains under trees, as against perhaps fifty per cent. before intensive settlement began.

When this occurs, the study of the forest, and of its life and growth, becomes a serious pursuit. For from it alone can be obtained timber, a product essential to modern civilization in a thousand different forms. Building timber, flooring, furniture, pit-props, poles, sleepers, paper-pulp, plywood, matches, charcoal, firewood, all are derived from forests at home or abroad. To this must be added the value of the forest as a place for recreation and sport, its influence on local climate, soil erosion, and water supply. Therefore the knowledge of how to conserve and, if necessary, extend, the forest resources of the land, takes its rightful place amongst the useful arts and sciences.

By those who favour definitions, a forest may be defined as an area of land covered by trees. It may be a large area or a small one. Three trees may form a miniature forest, provided they cover an area of ground and affect the soil and wild life thereon. Special definitions of the word include a royal hunting preserve, an area of woodland forming a unit of a forest administration, or a wild deer preserve, but these only apply in their own particular cases. The word " forest," like the idea it conveys, is of great antiquity, and its origin is somewhat doubtful. It was unknown to the Romans, and a derivation still given by many dictionaries, from *foris*, the Latin for " outside," is a pure supposition resting upon vague and unconvincing documentary support. More probably, an old Frankish word of the time of Charlemagne (*circa* A.D. 800) gave rise to both the modern

B

German *Forst* and the modern French *forêt*. It was Latinized by medieval scholars as a noun *foresta*, with many variations and derivations. It reached England in 1066 in the speech of Norman courtiers, and slowly supplanted its Anglo-Saxon equivalent *fyrthe*. This word still survives in place names such as "Chapel-en-le-Frith," in Derbyshire. It probably stems from the same Teutonic root as "forest" itself, so that this has been used by our forbears, in one form or another, since the days before history, since the time before the English speech had developed in England.

Two main types of natural forest occur in Britain. One is the evergreen coniferous woodland of Scots pine, now restricted to the Scottish Highlands, but formerly extending southwards to the river Trent. The other is the deciduous broadleaved woodland in which oak and ash form the main species, found throughout the British Isles but reaching its best development in the south. But the greater part of the afforested land has been planted with trees by man, and many foreign species of trees have been used, frequently in mixture with the native trees.

Natural forests arise slowly. When new land, such as a recently formed island, first becomes fit for plant life, it is invaded by grasses and herbs. These are succeeded by shrubs and bushes, which gradually suppress the softer plants below them by reason of their perennial growth and the shade which their leaves cast. They in turn are suppressed by the forest trees, which force their way, as slender saplings, through the thickets of thorn, bramble, or willow, and in the course of years expand their crowns of foliage above them. Then shrubs and herbs beneath perish alike from lack of light and the competition of tree roots for mineral food.

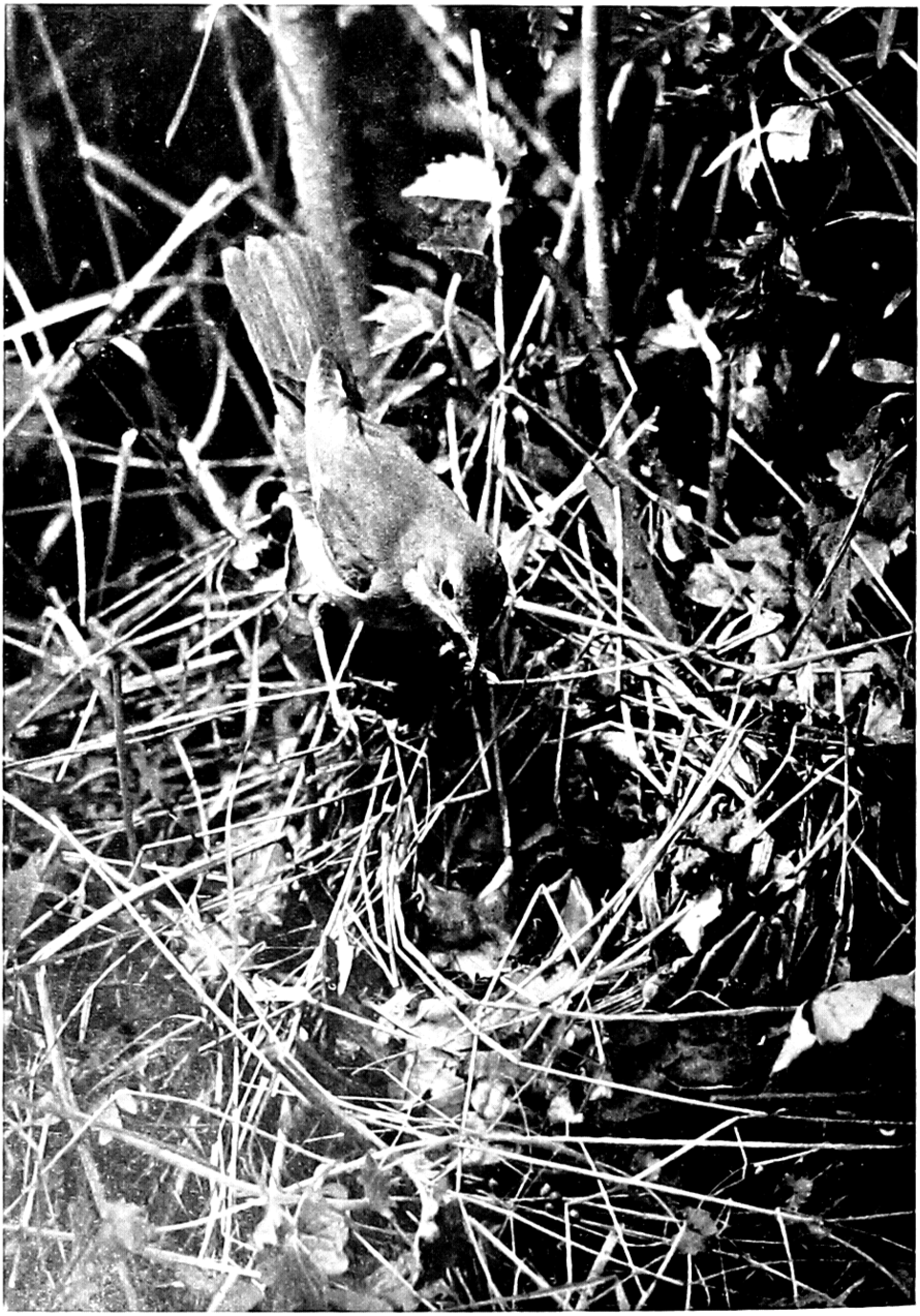
Once formed, the forest tends to persist indefinitely. Its trees live to a great age and seeds fall in profusion. When any tree finally dies and falls, scores of seedlings and saplings are waiting below to replace it. When sunlight strikes through the gap in the forest roof, their growth is stimulated and they strive amongst each other for mastery. Growing upwards in close competition, they increase in size as their numbers decline, until at length a single dominant tree occupies the space left vacant by the fallen giant.

The forest as a whole continues its existence unaffected by these changes in its composition. It is built up of many trees of all ages. Whilst individuals come and go, grow or decline, the community of the trees persists. Constant local changes leave the main structure unimpaired. If there be several species of trees, one may increase in numbers at the expense of another, or even succeed it entirely, but the forest structure persists. Only a drastic change in climate, or the hand of man, will cause its decline.

In Britain the decimation of the natural forest is due scarcely at all to climatic changes. In certain western districts, particularly in Scotland, increased rainfall may have promoted the growth of peat bogs so that they engulfed forest land. But elsewhere the disappearance of the woodland has been the result, direct or indirect, of man's increasing activity.

The mere felling of trees may not destroy the forest, for seed and seedlings are ready to replace the fallen giants. But husbandmen in need of land would often go farther and grub up the stumps and roots, thereafter converting the woodland into ploughland. When wage levels were low and land prices high, this process, known as making "assarts," was quite

4 WILD DAFFODILS IN A HEREFORDSHIRE COPPICE



5 A NIGHTINGALE AT ITS WOODLAND NEST

economic. Less obvious but equally serious damage was done by domestic animals grazing in the woods. These destroyed the tender shoots of saplings, so that when the old trees died or were felled, there was nothing to replace them. Next, man introduced the rabbit, and in the interests of game preservation, destroyed many of its natural enemies. Spreading unchecked, the rabbit destroyed, and in places still does destroy, the seedling trees as fast as they arise. In the hill country, the practice grew up of burning great areas of heath and grass to improve the pasture for sheep, and seedling pines and birches were consequently destroyed. In the plains, the scything of bracken for bedding down farm stock destroyed young oaks and beeches. Finally, the wolf was exterminated, and deer bred without natural checks and browsed upon the saplings.

The decline of British woodland is due in part, therefore, to a direct attack upon it in order to convert the ground to other uses, and in part to an upset of the biological balance, whereby the enemies of the trees are protected from their natural foes. Fortunately the reverse process of afforestation has made some headway, and planted woodlands, very different in composition from the wildwood, but usually better adapted to the needs of man, may be found all over Britain.

Their management requires a careful study of the factors which influence natural woodland and originally brought it into being, the most important of these being the life pattern of the trees themselves. Next come the basic conditions of soil and climate under which the trees grow, and then the various species of tree, native and foreign, as they grow in natural adaptation to each environment. Important also are the minor plants of the woodland, especially the fungi which not only cause certain tree diseases, but also do significant work in forest soils and the nutrition of tree roots, besides being largely responsible for the decay of timbers. Insects, which usually do only minor damage in their attacks on trees, may gain the upper hand if they are not suppressed by other insects or by birds. Although certain birds and many mammals feed upon trees in their younger stages, and may prevent their reproduction, others are helpful because they destroy harmful animals or insects.

Only when these natural factors are understood and assessed, is the forester able to proceed on a sure footing with either the formation of new woodlands or the maintenance of established ones. The forest which he preserves or creates will have its own influence on the wild life of the surrounding country, and if it thrives, will provide not only a profitable supply of timber but also a source of interest and beauty for all who encounter its leafy shades. For in the forest the rhythm of season and weather reveal themselves through the growth of the trees. The uncrumpling fragile buds of spring, the green mantle and canopy of summer, the glorious russet browns of autumn, and the fantastic white winter coverings of frost and snow, mark the passage of the years that add to the stature and value of the forest giants. Wind, cloud, and sunlight reveal new beauties amidst the bare branches or dancing leaves. Rare birds and shy four-footed creatures carry on the intricate business of their lives in the woodland depths, and the ring of the axe proclaims man's mastery over the forest realm.

CHAPTER 2

THE GREENWOOD TREE

A tree is a land plant that forms, or tends to form, a single, erect, rigid, and woody axis known as a trunk or bole. This trunk endures over a number of years and enlarges in height or girth, usually in both. It is not possible to draw a strict dividing line between trees and allied forms of plant life.

The word " tree " is derived from the Anglo-Saxon *treow*, and is of very ancient origin, connected with the Sanskrit *drus*. Trees have been known to man since the days before his speech first began.

Trees usually arise from seeds, less frequently from *sucker shoots*. Sucker shoots are thrown up by the roots of an established tree, and gradually assume a separate identity of their own (117). This is known as *vegetative reproduction*.

Seeds arise during the process of *sexual reproduction*, being borne by the female portion of the tree's flower. They vary widely in size and appearance, from the large edible seeds of the Sweet chestnut to the tiny winged seeds of the Silver birch. Each contains a whole plant in embryo, but this lies dormant until it finds the right conditions of warmth and moisture. The seed is the dispersal stage of the tree, by means of which the species spreads over the face of the land. It may be carried by wind, birds, land animals, or water. The power of growth, or *viability*, is retained for varying periods, — a few weeks in the case of aspen, a few years for the commoner conifers.

If the seed lights upon a favourable spot it germinates, usually in spring, but sometimes in autumn, whilst certain seeds lie dormant for a year or more after they fall. On germination, the seed develops the first and most fundamental organs. A *root* dives down into the soil to find anchorage, water, and mineral nutrients. Then a green *shoot* arises into the air, to expand its leaves which assimilate the carbon-dioxide of the air to form carbohydrates. This first effort is made by oxidizing the food substances stored within the seed, to provide energy through the process of *breathing*. That slender store of food is soon exhausted, and thenceforth the seedling tree is entirely dependent upon the light and warmth of the sun for all the energy required by its processes of life and growth.

The seedling tree has many enemies, animals which devour it or faster-growing plants which may suppress it or crush it down. But if it survives them for a season, it forms a *winter bud* at the tip of its shoot before it rests for the winter. Next spring its growth is re-commenced from this advanced outpost (11-13). The tree has thus a start over its herbaceous competitors, the plants which start their seasonal growth from ground level. If it escapes serious injury, it will continue to outgrow them until at length the shade of its leaves deprives them of their vital source of energy,—the sunlight.

From fifteen to fifty years normally elapse between the germination of the seed and the fruiting of the resultant tree, varying with species and situation. During this period the tree grows not only taller but also thicker and stronger. Its stem throws out branches to form the *crown* of the tree, whilst a similar expansion occurs amongst the roots. At length the tree bears flowers and seeds, sometimes every year, sometimes only at intervals of two or three years, again varying with its species. These flowers may each contain the organs (*stamens* and *carpels*) of both sexes (*hermaphrodite flowers*), or the sexes may be segregated into different flowers on the same tree (*unisexual* or *monoecious flowers*), or again the sexes may be borne on quite distinct trees (*dioecious flowers*). Pollination, or the transfer of pollen from stamens to carpels, is effected by wind or insects, and after the ripening of the resultant fruit, the seed falls to the ground to begin the life cycle again.

The parent tree continues to grow and thrive, producing in its lifetime many thousands or even millions of seeds to ensure the continuance of its race. But ultimately it reaches the limit of its growth. Then it may persist for perhaps a hundred years without either increasing in size or declining through decay. At length, however, its course is run. It may fall the victim of some swift disease, or more probably slowly go under through the work of some hidden fungal decay that saps the strength of its heartwood until the winter gales find it an easy prey to their wrath. Then it falls, to moulder on the forest floor in the shade of the daughter trees that soar upwards to replace it.

From the above account, it may be seen that although trees follow the general trend of plant life, they grow on a scale and at a *tempo* that is all their own. There is no fixed limit to the growth of a tree, either in height, girth, or the spread of its crown. Outsize figures for these items are respectively 364 feet tall, 26 feet in diameter of the trunk, and 30 yards radius of the crown. Individual trees have been measured with 50,000 cubic feet of timber in their stems. These are, of course, world records such as are not attained by any trees at present standing in the British forests, though they were reached by trees, such as the sequoias, which have been introduced and are thriving here. At the other end of the scale, trees a score or more years old may produce stems only a few inches tall, as is shown by the trees artificially dwarfed by Japanese gardeners. Species plays a large part in deciding the size attained, but *environment*, meaning the natural surroundings in which the tree is obliged to grow, is even more important.

The life-span of trees is also indefinite, but some species seldom exceed one hundred years of age in the best of surroundings, whilst others go on to exceed three thousand. Rate of growth is consequently variable. As a rule-of-thumb, it may be taken that a foot a year in height growth is an average figure for the first hundred years. Again, trees vary from place to place, from species to species. Growth in girth of trunk normally continues long after height growth has ceased.

A tree is not merely a very large land plant. It is a land plant adapted for indefinite expansion in size and indefinite duration in time. In considering its structure and the life processes that make its life cycle possible these differences must constantly be kept in mind.

TREE STRUCTURE. Trees, like other plants, are built up of an enormous number of *cells*, each of which is a minute box-like unit of structure. Within the fibrous cell walls are found a living, more or less liquid substance called *protoplasm*, and a *nucleus*. This nucleus is the centre of the cell's activity. Although each cell is but a microscopic part of the organism as a whole, every cell nucleus contains the controlling elements of the whole plant. This explains how a new tree can grow from a small detached portion, such as a cutting. Cells increase by division, the nucleus always dividing also.

Every living cell requires air, water, and a supply of essential elements and chemical compounds.

The specialised tissues of plants are composed of numerous cells adapted to various functions. In trees, adaptations occur which are not found in herbaceous plants. Wood is built up of cells designed for strength, storage of food reserves, or the transport of sap. The highly-modified fibrous wood cells are the source of the strength of timber. They are also of great utility to mankind for the manufacture of wood pulp, paper, cardboard, and similar fibrous products.

GROWTH AND NUTRITION. The essentials for tree growth are :

Firstly, a roothold upon the earth.
Secondly, an ample supply of sunlight.
Thirdly, adequate fresh air.
Fourthly, ample water at the roots.
Fifthly, a supply of soluble chemical nutrients in the soil.

Two of these essentials are physical, the hold upon the earth and the life-giving light energy of the sun. The other three are chemical, and relate to the constituents directly involved in the formation and metabolism of the tree's tissues.

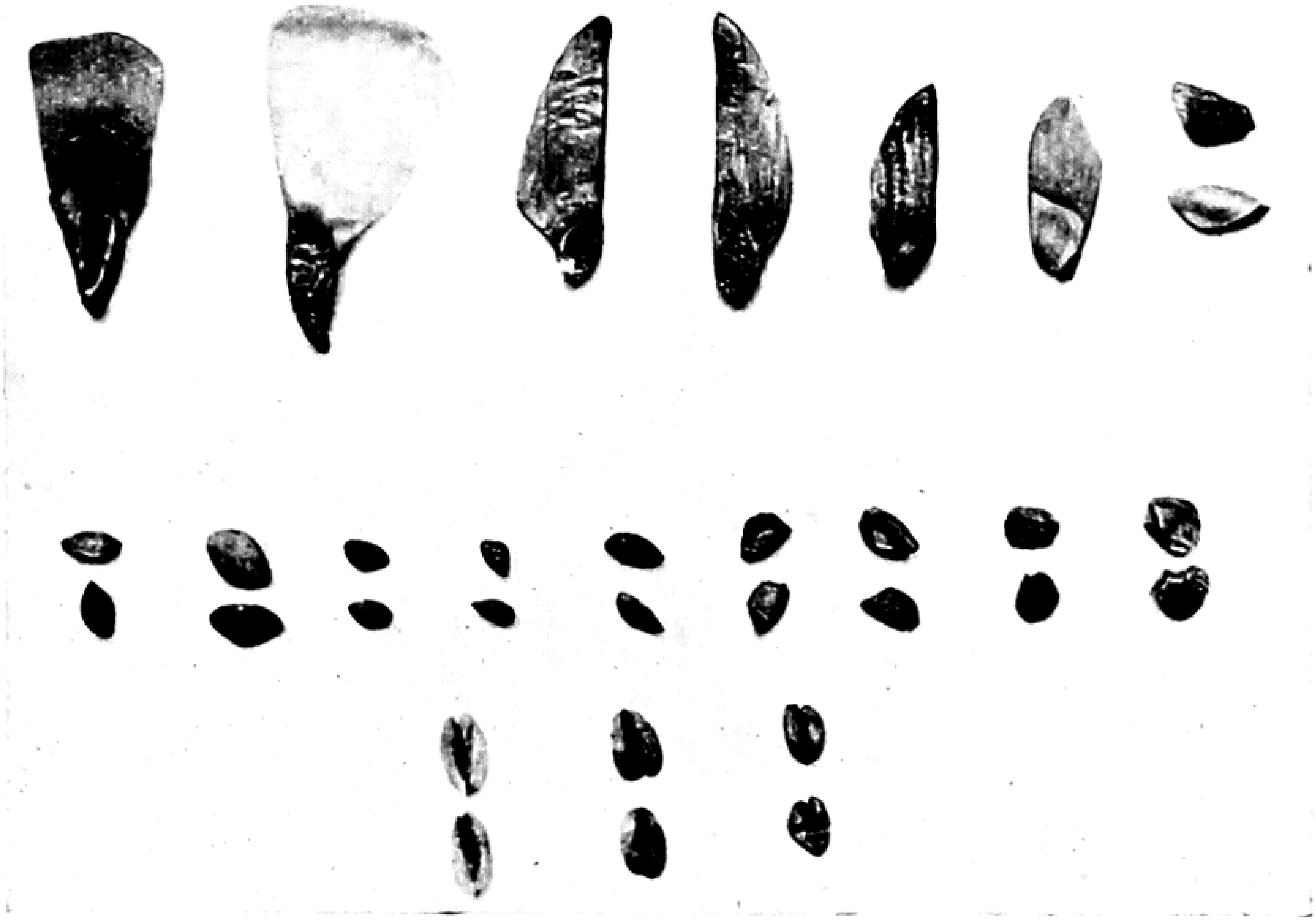
The most fundamental of all the tree's life processes is *breathing*, which supplies energy for the activity that goes on within its cells. Breathing consists of the oxidation of certain carbon compounds (carbohydrates) in the tree's cell sap, so that they combine with the oxygen of the air to form carbon dioxide gas. This process, which is common to both plants and animals, releases energy.

Every living cell of the tree must breathe, the roots and trunk as well as the green shoots. Sometimes the roots obtain air from running water, but they cannot thrive in stagnant water nor in a waterlogged soil. Hence the importance of draining forest land. On the trunks of most trees, special pores called *lenticels* appear ; these have the function of supplying air to the tissues beneath. The green leaves, which need most air, obtain it through minute openings termed *stomata*. Breathing goes on by night as well as day; it needs no light energy, being itself an energy-producing process.

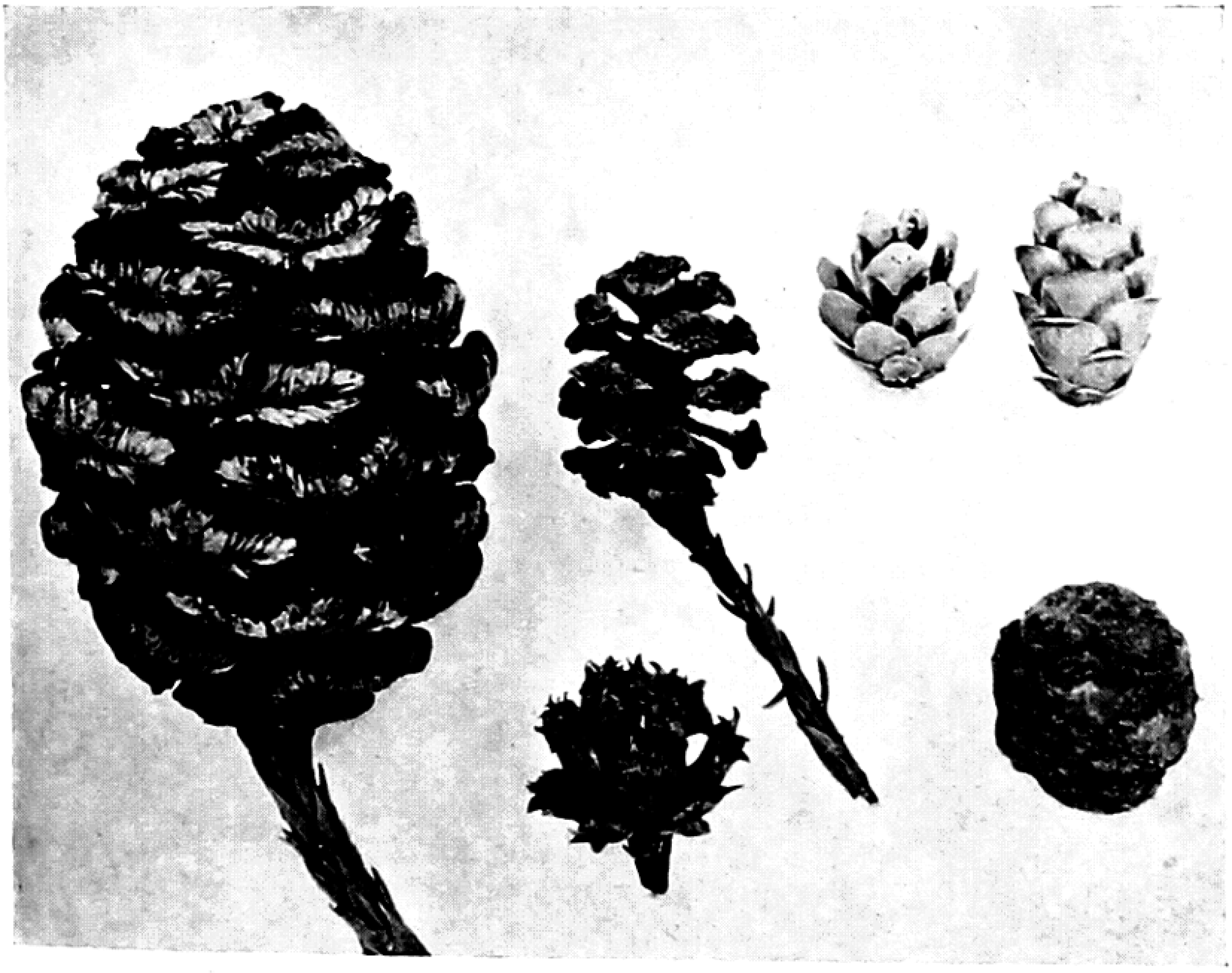
Next in importance comes the *absorption* and *transpiration* of water. Water is an essential constituent of every plant cell. It is taken in by the roots, and passes along special tissues through the roots and trunk to the leaves, from which it escapes, in part, to the outer air. Throughout this journey its passage is carefully controlled from cell to cell.

Along with the water of the soil, the tree's roots absorb minute amounts of dissolved *mineral salts*. Most important are the salts of the elements nitrogen, phosphorus and potash, but also essential are those of calcium, iron, magnesium, chlorine, sodium, and sulphur. Other elements may be needed in extremely minute quantities. These form essential constituents of the plant's tissues, or act as catalysts in bio-chemical reactions. The other three vital elements, carbon, hydrogen, and oxygen, are obtained from air and water.

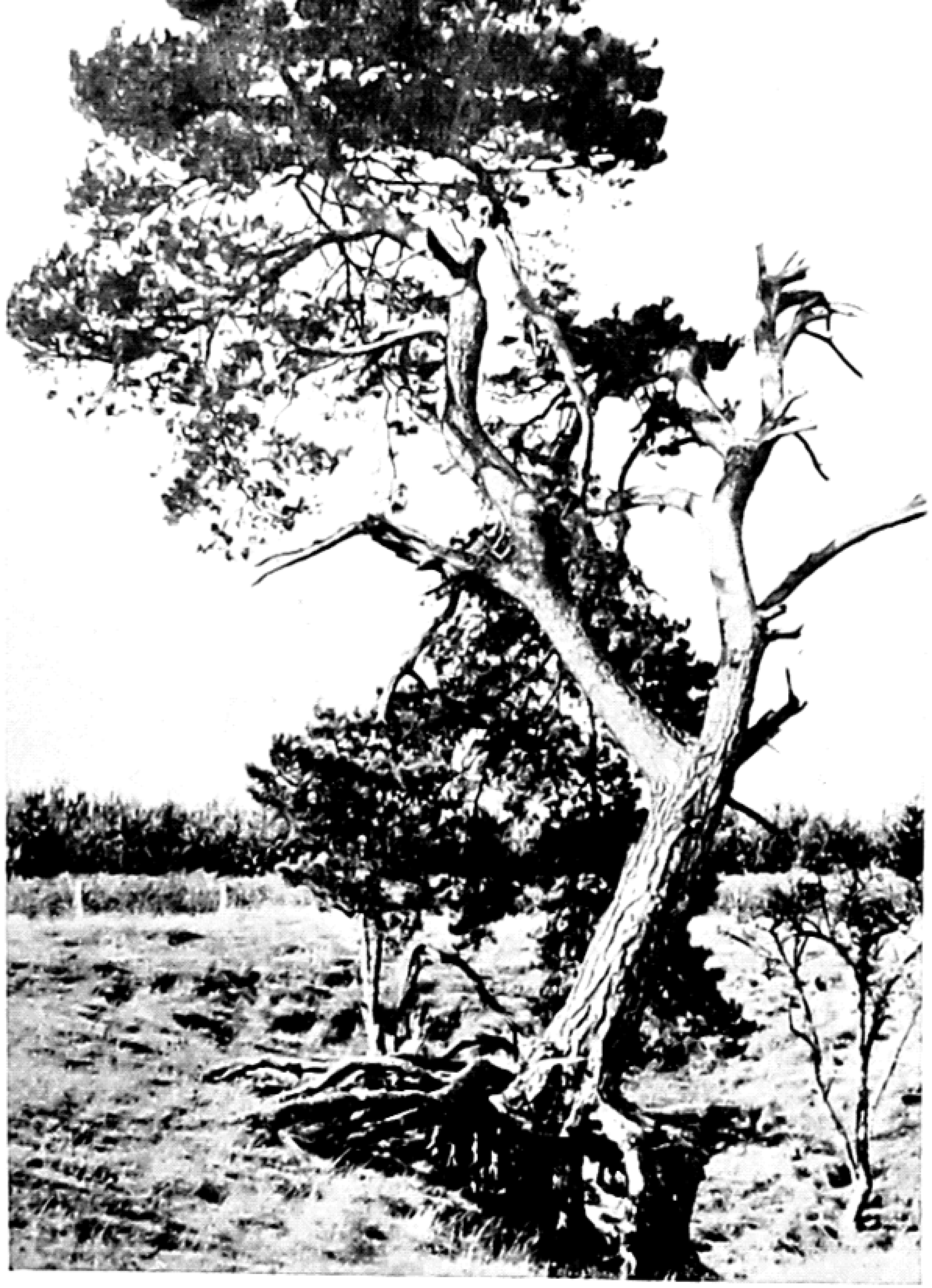
The amounts of mineral nutrients of various kinds available vary from one soil to another ; the amounts required vary from tree to tree, according to size and species. But a tree, unlike a herb, is continually thrusting its



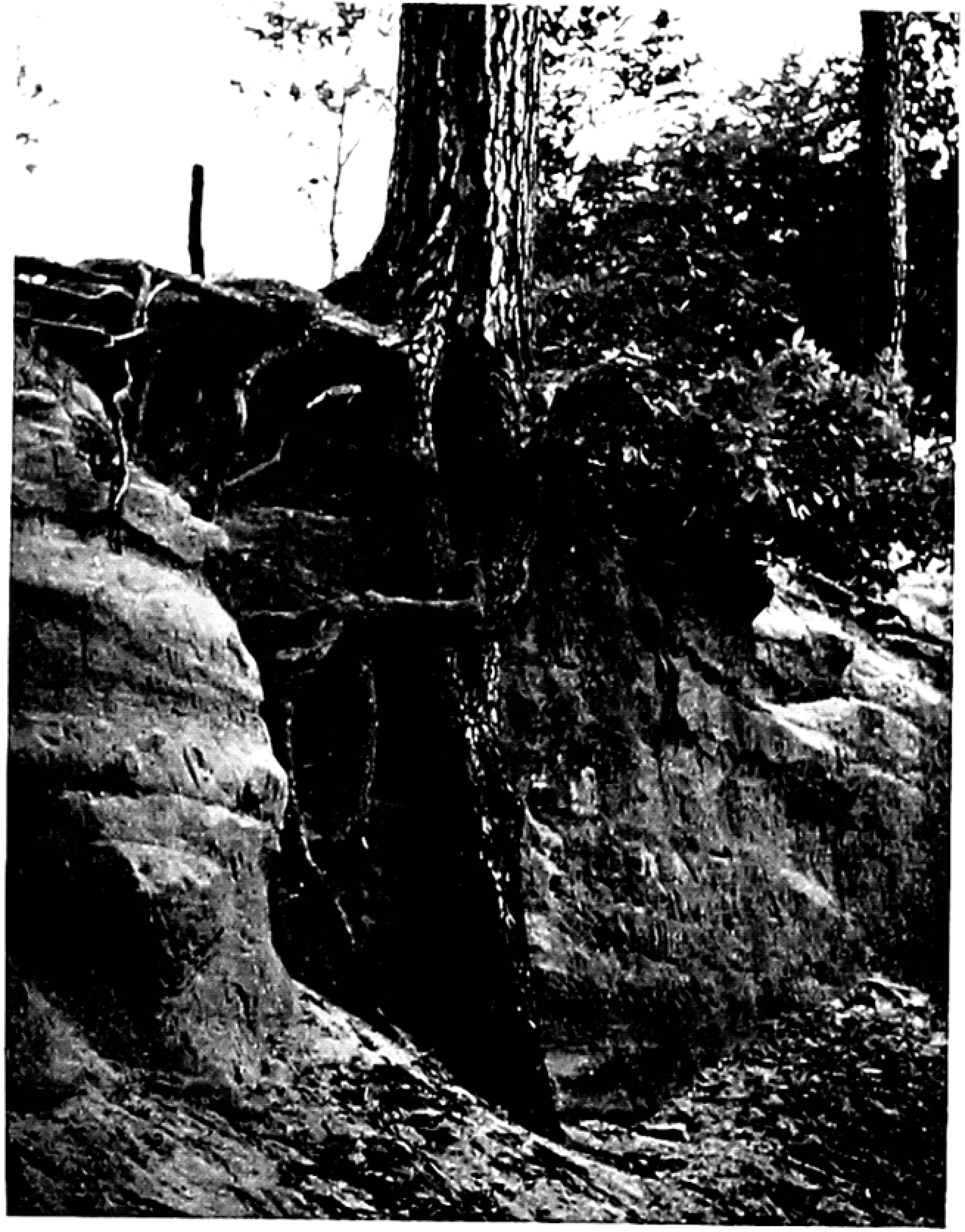
6 SEEDS OF SIXTEEN DIFFERENT CONIFERS, ONE AND A HALF TIMES NATURAL SIZE, WITH AND WITHOUT THEIR WINGS



7 SEED-BEARING CONES OF BIG TREE, REDWOOD, EASTERN AND WESTERN HEMLOCKS, JAPANESE CEDAR, AND SWAMP CYPRESS



8 SIDE ROOTS MAY SERVE AS SUPPORTS OR—



9 ANCHOR THE TREE LIKE A TAP ROOT

ROOT HOLD, EXEMPLIFIED BY OPEN-GROWN SCOTS PINES roots wider and deeper. By tapping an ever-increasing volume of soil, it usually obtains enough mineral food for continued growth on all but the very poorest of sites; though certain species, such as oak, only form stems good enough for timber on the more fertile soils (8, 9).

The fourth factor in the nutrition of the tree is known as *photosynthesis.* This is carried out in the leaves and green shoots only, and only occurs in the light, which supplies the requisite energy (10). A green substance termed *chlorophyll,* evolved by the plant itself, plays an indispensable part in the process, which consists in the fixation of the carbon dioxide of the air in the form of dissolved sugar, itself a carbohydrate. Once this is achieved, the intricate chemistry of the tree can build up all manner of organic carbon compounds, either liquid or solid. Thus the tree obtains the greater portion of its substance from the air around it. It adds to its bodily form bit by bit as the years go on, for its principal raw materials, air and water, are available in unlimited supply. As it increases in size, so does its capacity for expansion increase also. It grows, in short, at compound interest.

Photosynthesis is the reverse process to breathing, but in any healthy growing tree the building up of tissues by the former process far exceeds the breaking-down of solid substances which breathing inevitably involves.

THE TREE TRUNK. The trunk, the distinguishing feature of all trees, has peculiar physical functions to fulfill. It must hold erect the tree's crown of foliage, and stay it against the sidelong force of the wind. It serves also as a medium for the transport of water and disolved mineral food *upwards* from root to shoot. It acts at the same time as a carrier of carbohydrates and substances developed therefrom, *downwards* from the shoot to feed the root. Further, it forms a storage medium, holding over food reserves from one growing season to the next, whilst its height aids the spread of seeds.

These functions are found to a lesser degree in the stems of herbs, but in trees the tissues that perform them are specially developed to a degree not found in herbaceous plants. The ultimate central core of the trunk is a tiny cylinder of pith, which persists from the time when the trunk was first formed, but later serves no effective purpose. Around this, the main central mass of the tree trunk consists of true wood or *xylem* tissue. This is a dense, complex structure of strong fibres, storage elements, and water conducting cells which perform the work of support, resistance to strain, storage of food reserves, and upward conduction of sap. All these cells are laid down by an outer layer of *cambium* cells, which divide to produce wood cells on their inner surface. This process of division forces outwards the cambium cells themselves, so that the *cambial ring* is constantly expanding. In spring the cambial cells are very active, producing wood with many sap-conducting elements as the needs of the season demand. In summer, they work more slowly, laying down more fibrous tissue to support the growing weight of the tree's crown. This alternation between the lighter spring and the denser summer woods, produces the *annual rings,* seen when the trunk is cut across.

These annual rings therefore indicate the age of the trunk *at the point where it is cut.* Obviously, the younger portions towards the top of the trunk contain fewer rings than the portions first formed at the base. The cambial " ring " is in fact a cone, which elongates with each year's growth of the tree, as well as expanding annually in diameter. Its activity varies from season to season. In a good year, when a tree is growing vigorously, a broad annual ring is formed, often half an inch in width. In poor seasons, or where a tree is growing under difficult conditions, the rings are much narrower. Wide ringed timber is termed "coarse-grained." Its formation is frequently welcomed by the forester, for it indicates rapid timber production, though not necessarily of the highest quality (14-16).

In broadleaved trees, special water-conducting tissues occur, known as *vessels*, which are just large enough to be seen with the naked eye. The radial tissues seen in many timbers are termed *medullary rays*, and serve chiefly for storage. *Heartwood* is laid down by certain trees at the centre of their stems. When a portion is no longer needed for the transport of sap, its cells are filled with tannins, resins, or gums which block them, at the same time rendering them stronger and more durable.

Outside the cambial ring, but also formed by it, lie the bast or *phloem* tissues. These conduct the food supplies *downwards* from the leaves to the roots, and are much smaller than the wood tissues. If they be cut through as in the process of ring-barking, the roots are starved and the tree dies.

Finally, the whole trunk is enclosed in bark, a protective tissue which varies with age and the species of the tree. This is formed from its own productive layer, the cork cambium.

A tree trunk is therefore a complex structure, and, thanks to the vital cambium, can increase in size to meet the increasing demands which the tree's growth make upon it. It grows under constant pressure from above, and wind-strain from every side, and must evolve the strength required to meet the stresses and strains. This flexible strength, inherent in every cell and fibre of the wood, is the source of the value of timber. Man converts to his own uses the subtly constructed substance that has served the living tree so well.

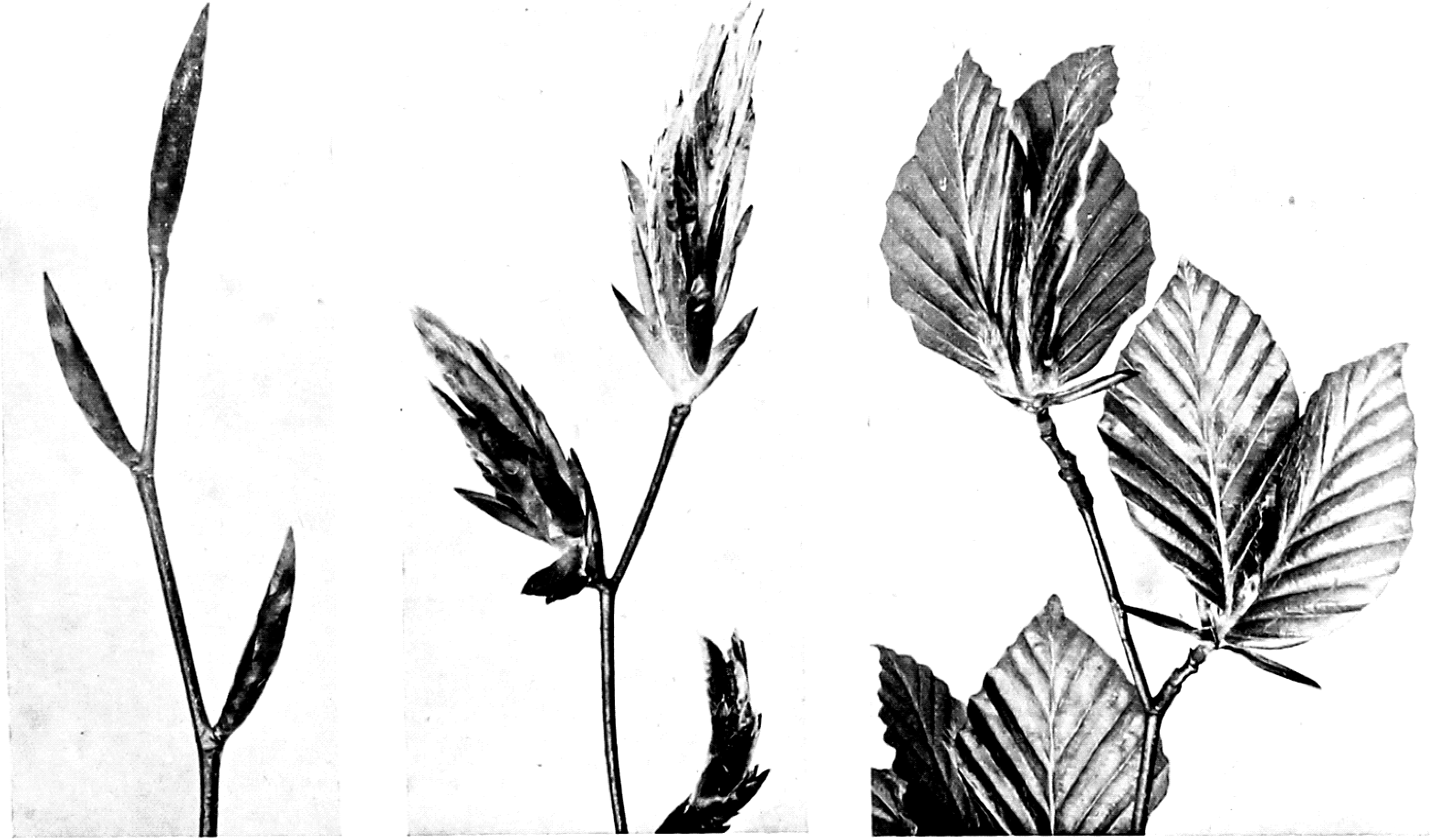
Not every tree produces useful timber, but most true trees can be utilised in some form or another. This cannot be said of the *shrubs*, which have many diffuse stems instead of a single central trunk; nor of the *woody climbers*, which have a flexible stem instead of a rigid one. These two forms of plant life are otherwise structurally similar to the true trees.

The branches and major roots of trees reproduce the structure of the trunk upon a lesser scale, but are less useful to man as they are seldom straight. Straightness is essential to economical working, especially with modern machinery. The conductive tissues of the stems and roots finally divide into slender bundles, which permeate the complex cellular structure of leaves, rootlets, and tree flowers.

REPRODUCTION. The organs of sexual reproduction are known collectively as flowers. They are produced by all trees, but not, as a rule, until their main growth has been made. Flowers consist of male and female elements, but in many trees these are borne separately in different flowers, or even on different trees. The male organs, termed *stamens*, produce pollen, which is transferred by wind or insect agency to the female portion, or *carpel*, of another flower. After this fertilisation, the carpel develops one or more seeds, which are ultimately released to produce new trees.

The number and design of stamens and carpels vary greatly from species to species. They are often accompanied by less essential organs,—*petals* which attract insects, *sepals* which protect the flower when in bud, and

10 HORSE CHESTNUT LEAVES CATCH THE SUNLIGHT, SOURCE OF ENERGY FOR ALL TREE GROWTH



11 12, 13 WINTER BUDS—— OPENING—— TO RELEASE NEW LEAVES

BEECH BUDS UNFOLDING IN APRIL

nectaries which secrete the nectar on which the pollinating insects feed.

Wind pollination is frequent among trees, so that their flowers, though complex and highly developed, are commonly inconspicuous, as they do not need to attract insects. The systematic classification of all plants is based on their floral structure, and shows that many of our trees are nearly related to certain herbs; for example, the tall wild cherry tree of the Surrey woods is placed in the same family as the humble strawberry.

The great group of the conifers, however, stands somewhat apart (7). Their flowers are primitive, and their wood lacks those vessels that conduct the greater part of the sap in the trunks of the broadleaved trees. Therefore in winter most conifers retain their leaves, as they can easily reduce the transpiration of water, especially as their narrow, needle-like leaves are well adapted to restricted evaporation. By contrast, in the cold British winter most broadleaved trees are obliged to shed their widely-expanded leaves. This leaf fall is linked-up with the factors of warmth, light, and available moisture. At low temperatures, even before freezing-point is reached, trees cannot obtain enough water from the soil to support the typical broad leaf; the few British evergreen broadleaves, such as holly, have leathery leaves adapted to reduce transpiration. " Evergreen " leaves fall after two or more seasons of life, but the tree is never wholly leafless.

This difference in physiology acts frequently to the advantage of the conifers, which grow rapidly on poorer soils and in colder situations than do the broadleaves. They are able to utilise the earliest warmth and sunlight of spring, whilst the leaves of the deciduous trees are yet in bud. As the cone-bearers habitually form straighter trunks, it follows that their cultivation is more immediately profitable to the forester. Moreover, the world demand for their softer, easily worked timbers, exceeds that for the harder woods of the broadleaved trees. In Britain, over 90 per cent. of the annual timber consumption is coniferous softwoods.

But it is the broadleaves that still strike the dominant note in the British forests. Although their profitable cultivation is not easy, their varied timbers have valuable technical properties, and outside the forest they are esteemed for shelter and shade, and as ornaments to the country scene. Orchard and garden trees are mainly of this group, so that its members are more familiar than are many of the cone-bearers planted chiefly in remote plantations. The rhythmic growth and decline of the foliage of such trees as oak, beech and elm provides one of the greatest attractions of the turning year.

The forests of Britain are not steadily, sombrely, evergreen, as are those of the tropics or the far north. Always there is change. In late spring, a myriad buds expand on every tree, unfolding delicate pale green or emerald leaflings that expand to form a many-shaded canopy of warm green. Throughout the long daylight of the short, intense, northern summer, this green curtain is busily at work nourishing the tree's growth, flowering, and fruiting, and making provision for its winter rest. In the autumn, or fall, the tree withdraws both sap and nutrients from the leaves, destined to fall when their season's work is done. As they fade, the disappearance of the green colouring matter reveals a vivid range of hidden tints, which change as the chemistry of withering proceeds. Then winter, and the gaunt branches stand bare, showing all the balanced beauty of their slender form, as the wild winds sweep through them, or frost and snow outline their graceful curves.

CHAPTER 3

NATIVE BRITISH TREES

The native British flora includes remarkably few trees of timber value. With the exception of certain forms of elm and willow, all these occur also on the mainland of Europe. The flora of Europe as a whole is much richer in timber trees than is that of Britain, but towards the north the number of species declines. Certain of our trees are growing at the northerly limit of their natural range, and others do not reach their finest development in these northern islands. Nevertheless, native trees still produce most of our finest timber, and in the case of broadleaves have not been replaced to any extent by imported species.

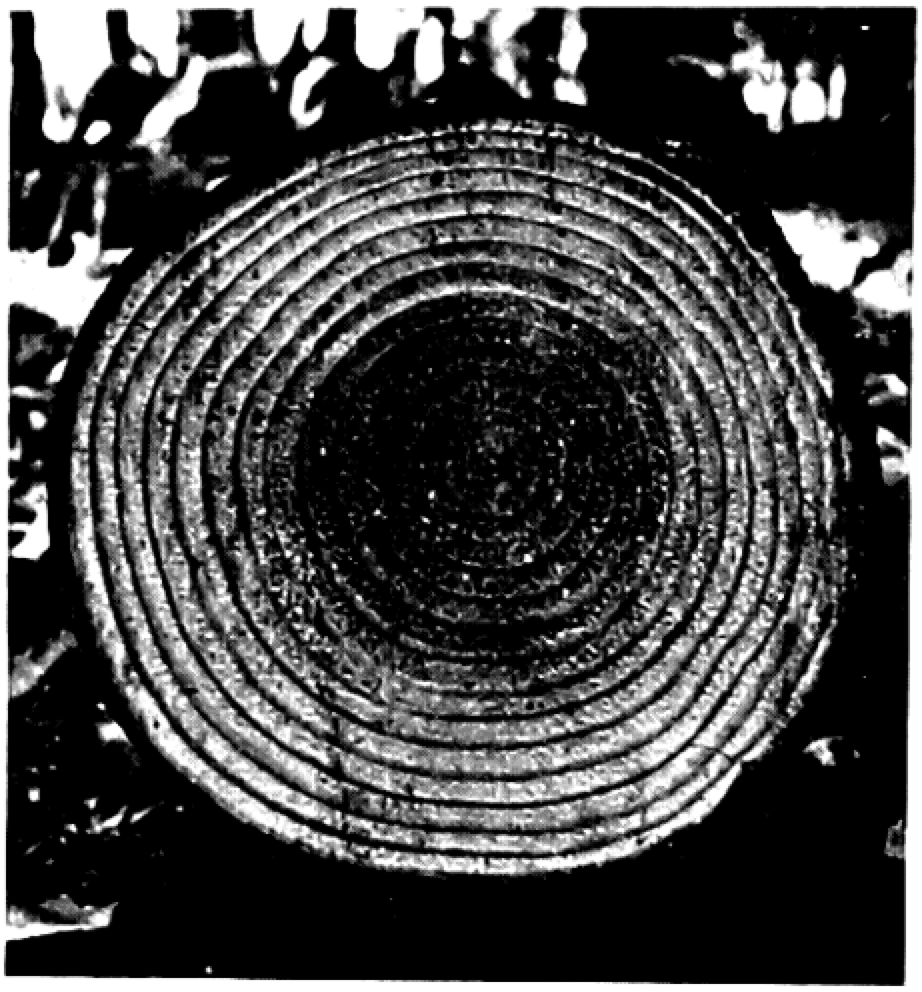
But as regards the conifers, it is frequently preferable to use foreign trees. This is due to the course of geological and climatic history. Many species of conifers, formerly plentiful in Britain, were exterminated by climatic catastrophes such as the Ice Ages, and did not return. The forester only reintroduces what has been lost. By selecting the trees most suited to our maritime climate, he is frequently able to obtain faster growth than is found in the more continental climate of the European mainland.

ALDER. Alder (*Alnus glutinosa* Gaertn.) (18) forms the natural tree covering of streamsides throughout Britain. It is a slender tree, with round, blunt-tipped leaves, recognisable by its bluish, stalked, winter buds, and the little false " cones " that hold its seeds. Its wood is soft in texture, and suitable for turnery work and the soles of clogs. It is a tree of secondary size and importance, and though existing stands may yield a useful return, it is seldom planted on any scale.

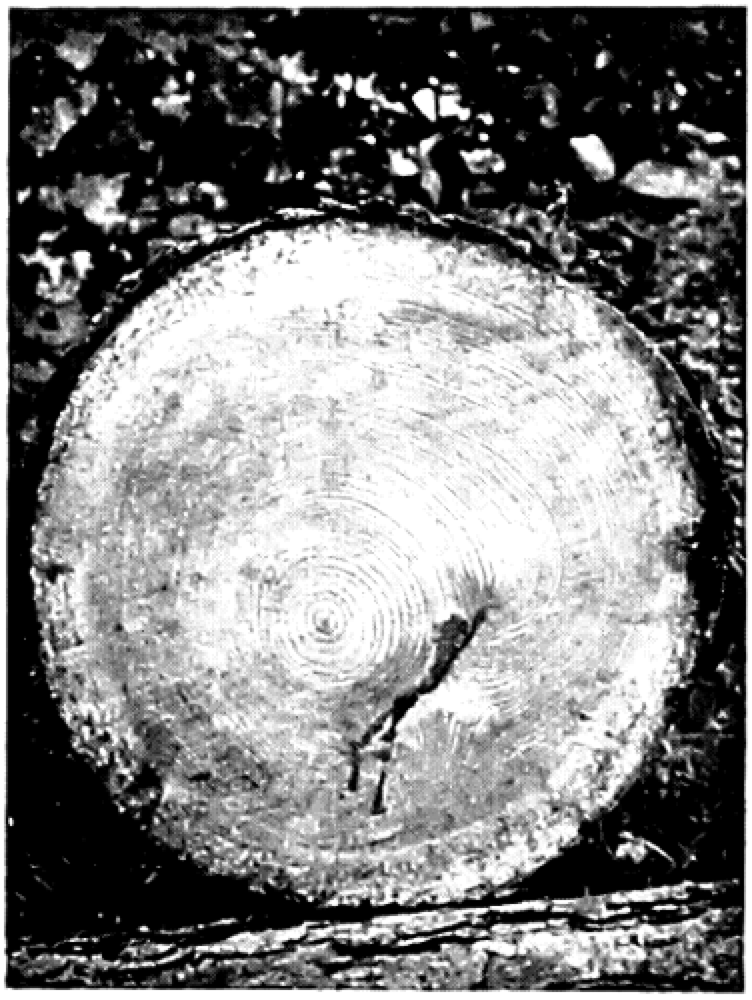
ASH. (*Fraxinus excelsior* Linn.) (109, 125). Found throughout Britain, the ash forms natural woods chiefly upon limestone soils, where it develops into a tree of great size and beauty. It is identified in summer by its compound leaf, in winter, by the hard, black, oppositely-placed buds; whilst in autumn it is usually rendered conspicuous by its clusters of winged seeds or " keys." Ash is the last of our trees to come into leaf, but on favourable soils makes good use of its short growing season. A light-demanding tree, it also makes heavy demands on the fertility of the soil, and can only be profitably grown in warm and sheltered situations.

Ash timber is remarkable for its elasticity, and is used for the handles of tools and sports gear, also in the framing of motor vehicle bodies. The English-grown timber is highly esteemed and usually fetches a higher price than other home-grown woods. Ash is a faster grower than oak, and more readily saleable in its smaller sizes. It proves a profitable plantation tree in suitable localities (152, 153).

BIRCH (2, 30). Occurring naturally throughout Britain, birch is usually a small tree and comparatively short-lived. Light-demanding and frost-hardy, it grows rapidly in youth, and may attain a height of 30 feet in only 12 years. But it rarely forms a trunk of much girth, or persists beyond the

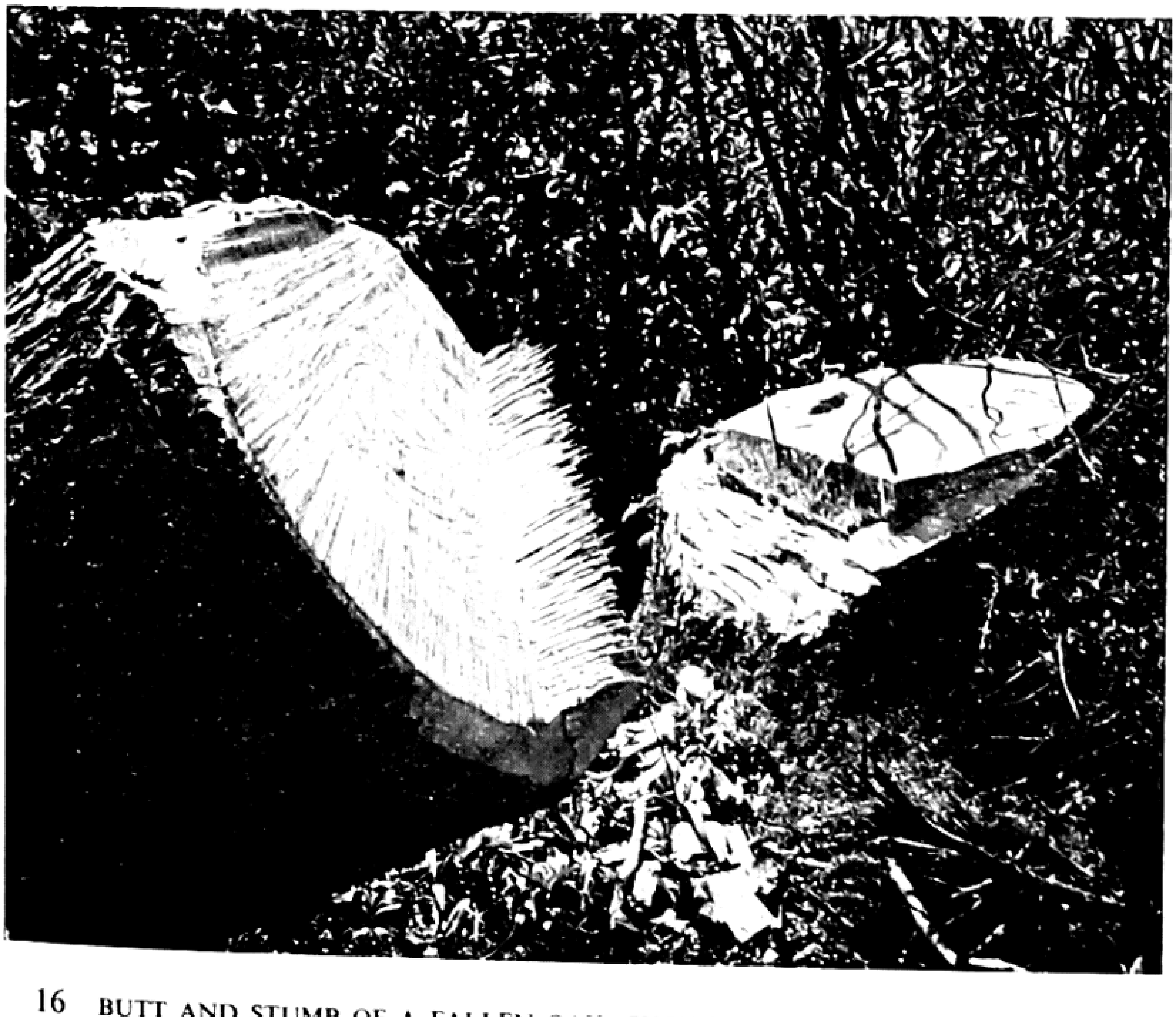


14 FAST GROWN, WIDE RINGED

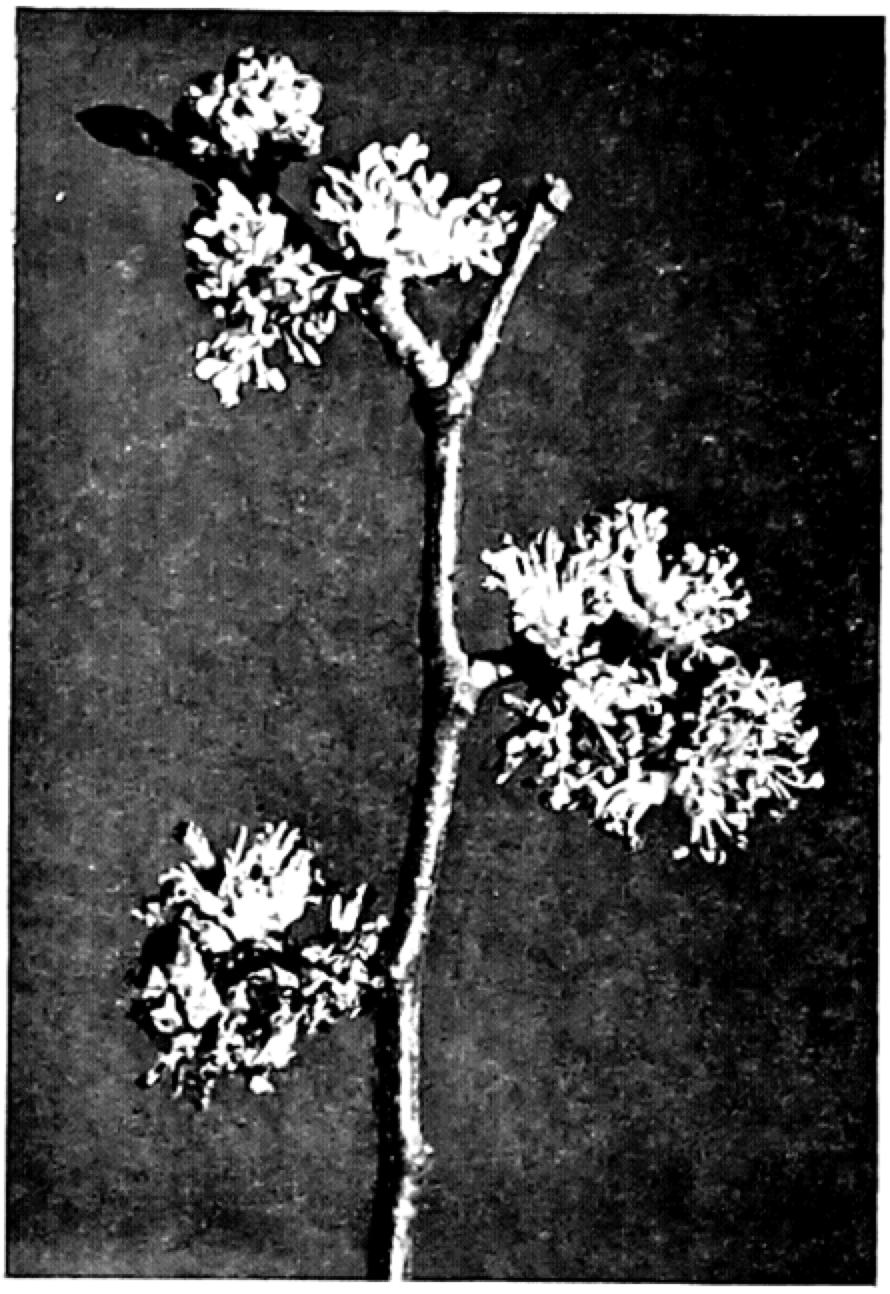


15 SLOW GROWN, CLOSE RINGED

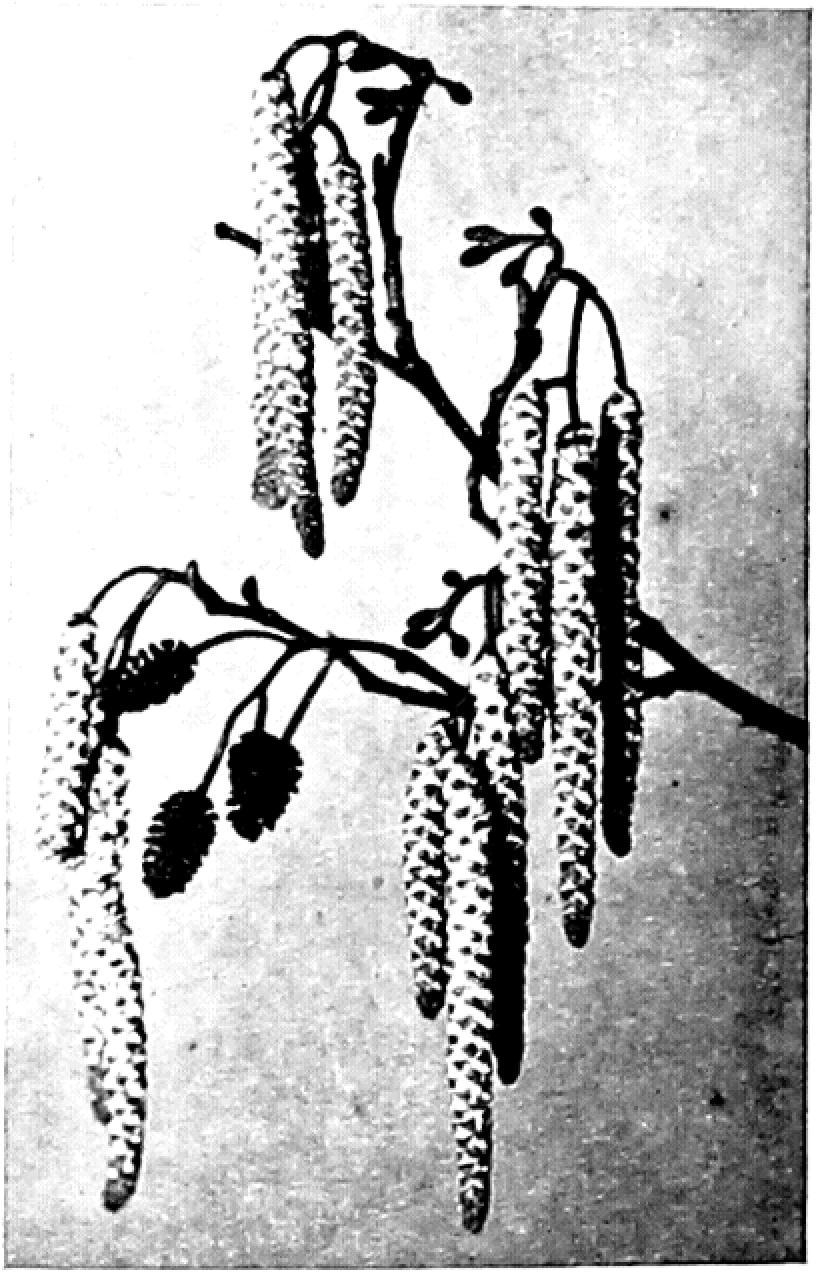
CROSS SECTIONS OF CONIFER LOGS



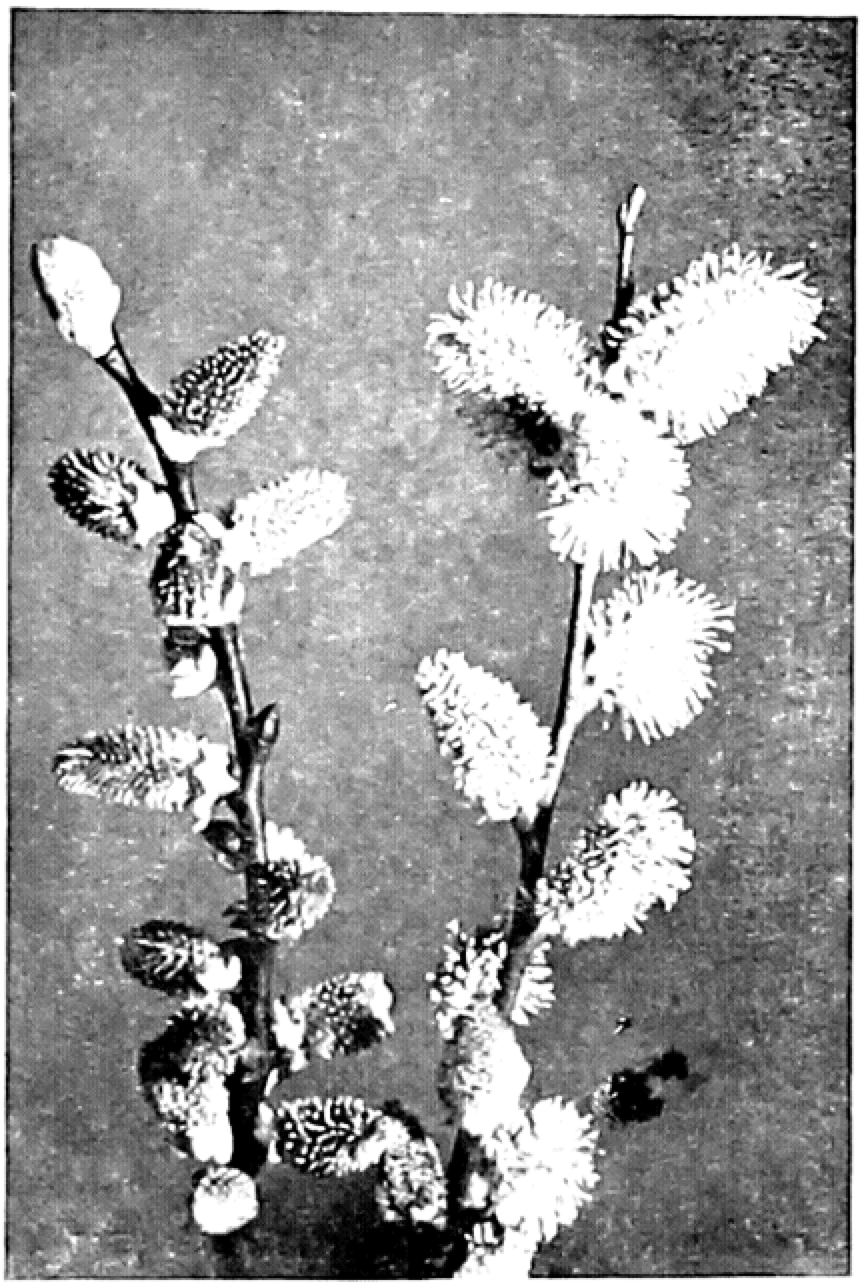
16 BUTT AND STUMP OF A FALLEN OAK, SHOWING ANNUAL RINGS AND THE MARKS OF AXE AND SAW



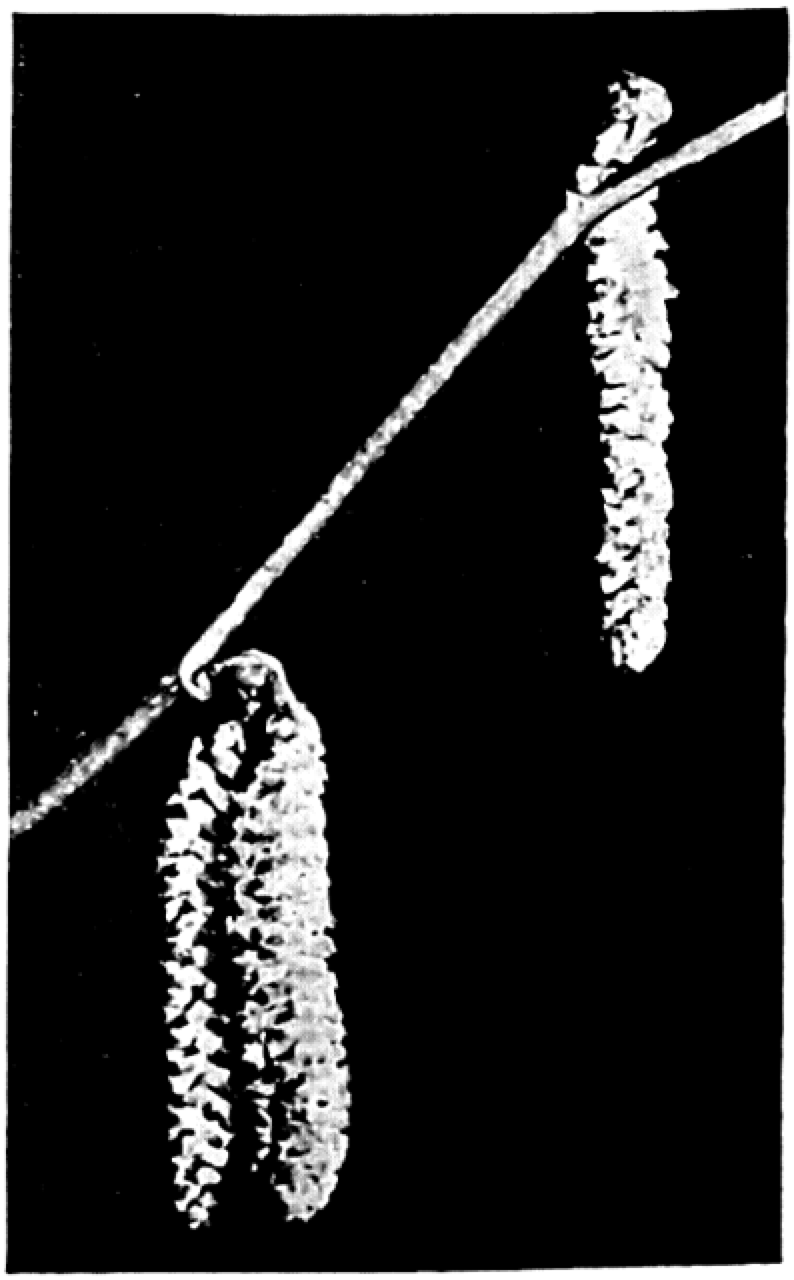
17 ELM FLOWERS IN FEBRUARY



18 ALDER IN MARCH; MALE AND FEMALE CATKINS, AND CONES



19 CATKINS FROM MALE (R) AND FEMALE WILLOWS, MARCH



20 MALE CATKINS OF HAZEL, JANUARY

CATKINS AND FLOWER CLUSTERS OF EARLY SPRING age of one hundred years. To compensate for this relatively short life-span, birch produces quantities of fine wind-dispersed seeds, which rapidly colonise new ground particularly on old woodland sites.

There are two species (*Betula pendula* Roth. and *B. pubescens* Ehrh.), very similar in appearance. Birch may be known at all times of the year by its thin whip-like twigs and the white, papery bark of the trunk. Birch is hardy, and thrives on all but the very poorest of soils. Its hard timber is not durable, and is used for making toys and small articles of wood turnery. In Scandinavia it is important commercially as a constituent of plywood, but in British woods it is more often regarded as a weed than as a commercial timber tree. Consequently, although trees of natural origin are utilised in fair quantities, Birch plantations are seldom established.

BEECH. (*Fagus sylvatica* Linn.) (21, 49). The beech is one of several trees whose natural range is restricted to a portion of Britain. As a wild tree it occurs in the south and south-east only, but under cultivation it has been carried far to the north, being commonly grown in the Scottish Lowlands. Beech is distinguished by its smooth grey trunk, its long, slender, pointed winter-bud, with brown, papery scales, its simple oval leaf, and its triangular nuts borne in a hairy husk. Beech is a shade-bearing tree, and its own leaves cast so dense a shade that few green plants can live beneath them. Its own seedlings, growing in this shade, struggle through to the stronger light above with difficulty. Seedlings of other tree species require more light, and so the natural beechwoods are remarkable for the absence of any trees other than the dominant beech. It attains great height and girth, and its age may exceed two centuries. Beech is partial to the better limestone, chalk, and sandy soils, and its heavy leaf fall forms a rich mould which nourishes the roots. It is subject to frost damage in youth, and although wind-firm when full-grown, benefits by the shelter of other trees in its early stages.

Beech timber is not durable out of doors, but its even grain enables it to be worked with ease in any direction. It is widely used for a variety of small articles where rigid strength is an asset, such as chopping blocks, lasts, plane-stocks, brush-backs, rifle stocks, and tableware; and is in demand for the commoner kinds of furniture, particularly bentwood chairs. The turning of small beech stems on primitive lathes is a rural craft that still survives in the Chiltern hills.

Once established, beech grows rapidly, and its cultivation is profitable to the forester. In the early stages, it is usually nursed by conifers, such as the pines, which are removed when the beech is well established. It is also used for underplanting light-demanding trees such as oak and ash.

ELM (17). The elms are remarkable for the wide variety of forms in which they occur. The most distinct species is the Wych elm (*Ulmus glabra* Huds.), known also as the Scots or Mountain elm. This is distinguished by its large rough leaf, lob-sided at the base, the stout winter twigs and buds, and the patterned fissures of its bark. As a wild tree, it occurs only in Scotland and northern England. Nowhere common, it forms small groves in the glens, where it reproduces itself by means of very numerous winged seeds. Its tough timber is durable under water, and is used by boat builders and box-makers, but it is of minor importance as a forest tree.

The Field elms, found further south, have usually a smaller leaf (which may be rough or smooth but is nearly always asymmetrical) finer twigs and buds, and a rough unpatterned bark. Certain forms, such as *Ulmus procera* Salis., attain great size, over a hundred feet in height, with wide-spreading crowns. Others, such as the Cornish elm, are pyramidal in form; and a number of hybrids and intermediate types are described collectively as " Dutch elms." The timber of all these is tough and difficult to work, but has an attractive grain. It it used for wagon boarding and kitchen furniture, also in boat building and the framing of crates and boxes.

Field elms require a rich soil, and are local in distribution, reaching their best development on the clays of the eastern counties, especially Essex. In the regions of poorer soil, they are often confined to river valleys. They have almost disappeared from our natural woodlands, and occur mainly in the hedgerows of the farmlands, where they most frequently reproduce themselves by sucker shoots. This mode of reproduction has helped them to survive the destruction of the forests that were once their home. They are seldom planted under forest conditions.

All the varieties of elm flower in spring before their leaves appear. The individual flowers are small, but densely clustered, and are obvious on account of their great numbers. The greenish fruits are masked by the opening leaves, and the winged seeds fall early in the summer.

HAZEL. (*Corylus avellana* Linn.) (20). Though never more than a shrub, the hazel has been of great importance in southern England as a *coppice underwood.* If cut back, it grows vigorously from the stump, producing small material used for hurdle-making, fencing, staking, in thatching, and as fuel, formerly also for rough building (wattle-and-daub) (105, 106). Coppicing can be repeated indefinitely at intervals of about seven years. As a wild shrub, hazel occurs from the Scottish glens to the Kentish downs. It may be identified by its bushy mode of growth, its broad leaf narrowing towards the tip, and the familiar cob nuts which appear between leafy bracts in autumn.

HOLLY (28). The evergreen holly (*Ilex aquifolium* Linn.) forms thickets in certain southern and western districts. Its glossy green leaf and red berry are familiar to all. The close-grained soft white wood is an excellent firewood, but is seldom utilised for other purposes, so holly is never planted for its timber.

HORNBEAM (111). Allied to the hazel, but resembling the beech in appearance, the hornbeam (*Carpinus betulus* Linn.) is frequently coppiced like the hazel, or *pollarded*, by cutting back at six feet above the ground, to secure small produce of the same class. As a wild tree, it is local in distribution, being commonest in the east but absent from Scotland. Its wood is so hard and difficult to work that it is no longer used on any scale in commercial forestry.

LIME (112). Two species of lime (*Tilia platyphyllos* Scop. and *T. parvifolia* Ehrh.) occur wild in England, but are rare and local. They are distinguished by their soft-textured, heart-shaped leaves, two-scaled winter buds, and the curious bracts attached to their clusters of flowers and fruits. Their timber is soft, but is suited to special work such as turnery, wood carving and pattern making. Except as ornamental trees, they are rarely planted.

MAPLE. The native Field maple (*Acer campestre* Linn.) common only in the south, is usually coppiced like the hazel, but if left to grow becomes a tree of moderate size. It may be known by its lobed leaf, corky bark, and paired winged seeds. The wood is used for fencing and turning, but is not planted commercially.

OAK (3, 23, 119). Foremost amongst the trees of Britain stands the oak. Under its shade the Druids worshipped their strange gods; indeed the similarity of its British name *derw* suggests a common derivation, so that " druid " may signify " oak-priest." In later times, its branches hid King Charles II from his pursuers, and its leaves were adopted as a symbol of loyalty to the crown. Its timbers formed the framework of the great ships which were not only the bulwark of Britain's home defence, but carried her seamen, warriors, and adventurers to the remote countries of her empire.

Oak is the commonest, most numerous, and most widespread of our native trees, and the natural vegetation of wide areas was formerly oakwood. The tree is of slow growth and its heavy seed does not enable the oakwood to spread rapidly. But the grown oak is so durable that it outlasts trees of other species, and so the oakwood persists, in fragments of its former greatness, throughout the land. Further, oak is tolerant of a wide range of soil and climate, and continues to grow and to reproduce its kind on sterile weather-beaten sites where it can never develop into fine timber.

Oak may be recognised in summer by the sinuous outline of its leaves, and in winter by the clustering of the buds towards the tips of the shoots. Its fruit, the acorn, is familiar to everyone, being an oval nut, borne in a semicircular cupule. There are two species, the Pedunculate oak (*Quercus robur* L.) and the Sessile oak (*Q. petraea* Liebe), but they are closely allied and hybrids are common. Its heavy seeds are eaten by squirrels, wood pigeons, pigs, and other animals. The few that escape develop quickly at first, but later growth is often delayed by spring frosts. Oak is very variable in form. In woodland it ascends as a slender tree, reaching some 80 feet in height in as many years, then expanding its trunk. This expansion of the trunk proceeds slowly, so that useful saw timber is seldom obtained under 120 years of age. In the open, oaks make much less height growth and run to wide-branched crowns, which results in a short trunk containing little useful timber. Oaks are light-demanders, but in their youth are sometimes nursed up by other trees of frost-hardy species.

Oak sapwood is perishable, but the heartwood is one of the strongest and most durable timbers known. It can be converted and utilised in many ways for constructional or decorative work. It varies widely in texture and grain, and although the British timber is as strong as any, it is exceptionally hard; that from other parts of Europe is imported (under a wide range of names) for such purposes as furniture making, as it is more easily worked. The bark can be used for tanning, and oak coppices were formerly maintained to yield bark, firewood, and small poles.

As a tree of the wildwood, where time is no object, the oak thrives so well that it is strange to find that the raising of a good crop of oak is considered an achievement of which the most skilful forester may be proud. But under cultivation oak requires careful tending in youth, careful thinning as it grows older, and finally an *underplanting* with another species of tree to keep the oak in good health. It grows so slowly that financial returns are a doubtful quantity, despite the high intrinsic and money value of its timber. It is best planted only on the richest of forest soils, for only oak of the first quality, in large dimensions, commands exceptional prices. Thriving oakwoods, with their wealth of green plants upon the forest floor, are attractive both to the commercial forester and to the nature lover.

POPLAR (29). Three species of Trembling poplars are native to Britain. The most widespread is the aspen (*Populus tremula* Linn.), a small tree with smooth round leaves which vibrate incessantly in the slightest wind. The White poplar (*P. alba* L.) and the Grey poplar (*P. canescens* Sm.) are commonest in the south, but are local in distribution. They form beautiful upstanding trees with white-barked trunks. Their lobed leaves, green above, white below, tremble in the wind and glitter in the sun. The tiny seeds of poplars are wind-borne, but these species also reproduce themselves by sucker shoots (117).

The European Black poplar (*P. nigra* L.) is confined as a possible native tree to the midlands and east of England. A coarse tree with rough bark and frequent swellings on the trunk, its branches make sharp angles with each other. The dull green leaves are large, triangular in outline, borne alternately on ribbed twigs. It is of rapid growth, and reaches great height and girth, but thrives best on the alluvial soils of fens and river valleys.

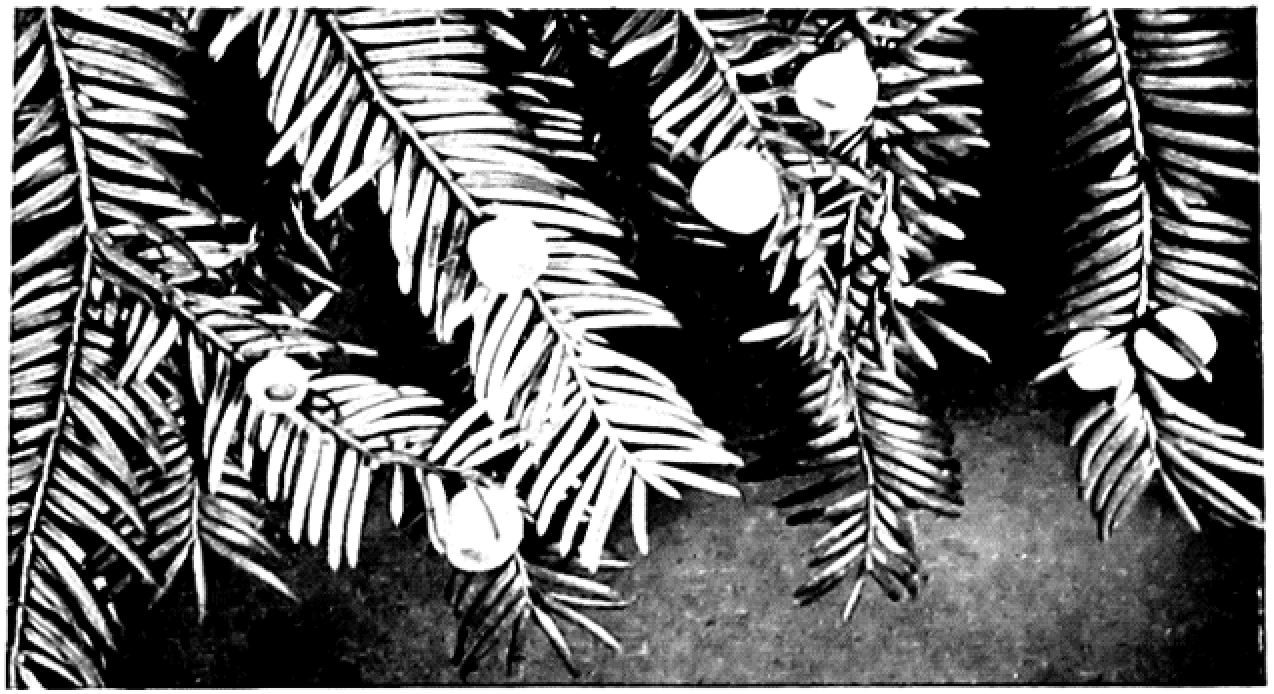
All the poplars are remarkable for their rapid growth. They flower before their leaves appear, and each tree bears flowers of one sex only. Their soft, light, timber is used for wagon bottoms, and is also of value in the match industry. Foreign species and hybrids, which grow even faster than the native trees, are generally used when making plantations.

WILLOW (19). A wide variety of willows occur wild in the British Isles. They range from tall trees to humble creeping shrubs, and whilst some are everywhere common, others are confined to small areas. The chief timber willows are the White willow (*Salix alba* Linn.), the Crack willow (*S. fragilis* L.), and their hybrids. Rarely found wild, they are common in the river valleys of the English midlands as pollard trees lining the sides of streams and ditches. Their timber is soft, light, and has special uses, such as chip baskets and cricket bats. Osiers of various species are cultivated as coppice in suitable riverside localities for use in basketry. Shrub willows such as the Goat willow (*S. caprea* L.) occur in damp places throughout Britain, whilst Dwarf willows are found on heaths and mountains. Willows have simple leaves, and winter buds enclosed in a single scale; their flowers appear before the leaves, each tree bearing those of one sex only.

TREES OF THE ROSE TRIBE. The natural order *Rosaceae* contributes a long list of small trees to the British flora. All are conspicuous for their white flowers which are pollinated by insects, and for their succulent fruit, usually edible. They include wild apples, pears, plums, cherries (182), and thorns (26), but most are very local in occurrence, and none plays a leading part in natural woodlands. The two commonest are the rowan (*Sorbus aucuparia* Linn.) (24), typical of the lighter soils of Scotland and the north; and the whitebeam (*S. aria* Crantz.), found on the chalk of southern England. The gean (*Prunus avium* L.), a form of wild cherry, is sometimes planted for timber. Its smooth bluish bark is prominently banded with lenticels or breathing pores. The brown-hearted timber is used in cabinet making.

SMALLER BROADLEAVED TREES AND SHRUBS. A variety of small trees which never attain timber size or play a dominant part in the woods, are found in the south of Britain. The principal ones are Spindle, Wayfaring Tree, and Purging buckthorn, all common on the chalk; Alder buckthorn, confined to fens and similar areas, and Sea buckthorn, restricted to the seashore. Dogwood (27), Guelder Rose, Elder (25), and Privet flourish on varied soils

21 BEECH NUTS

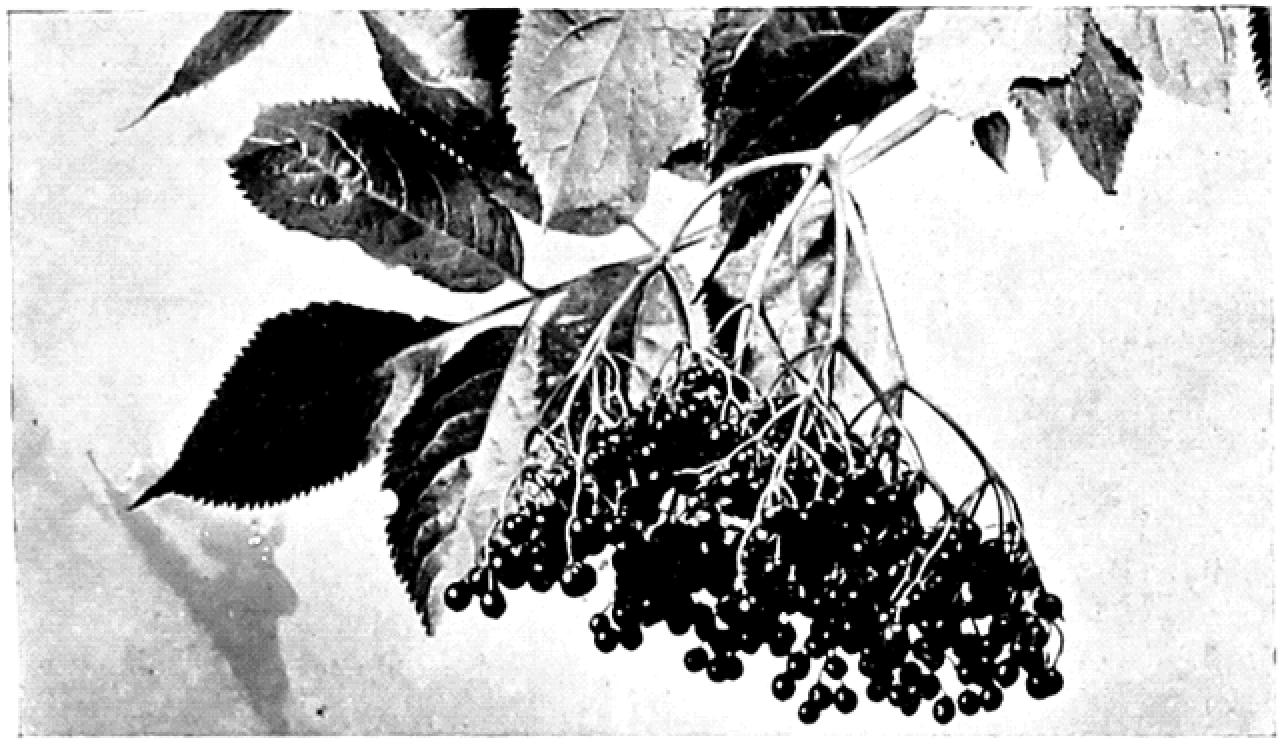


22 YEW BERRIES

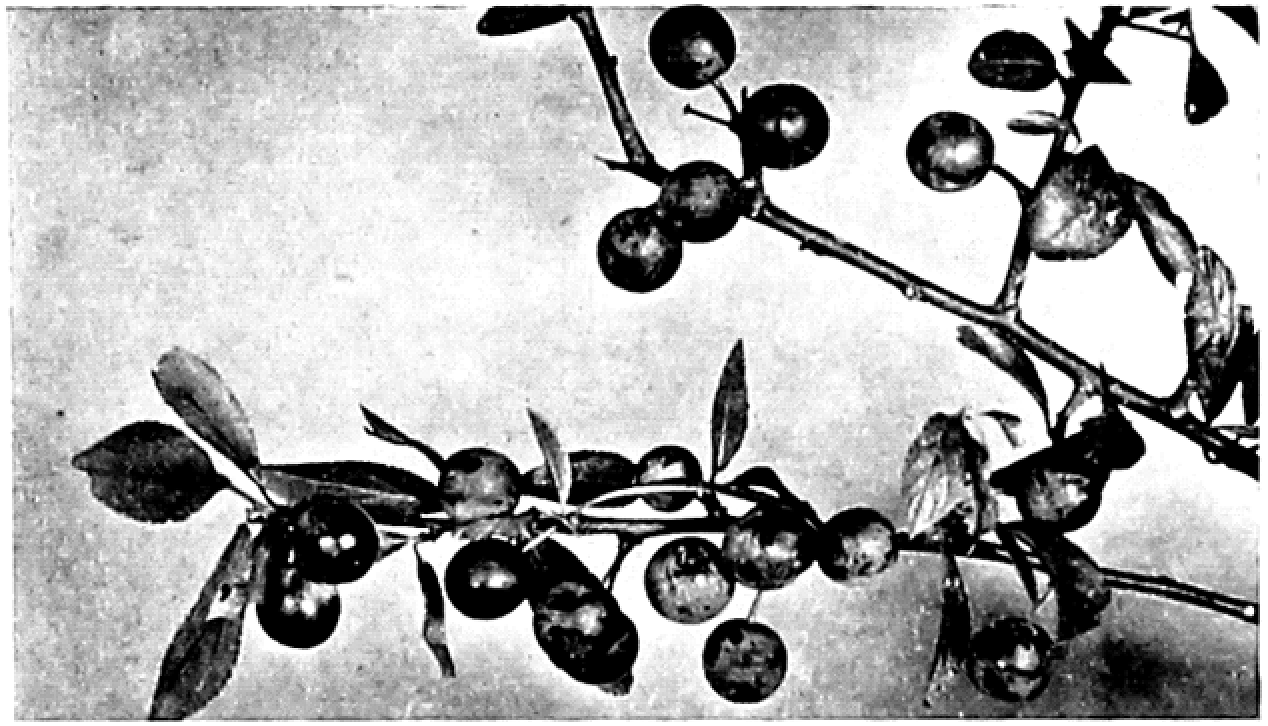
23 ACORNS, FRUIT OF THE OAK

24 ROWAN BERRIES

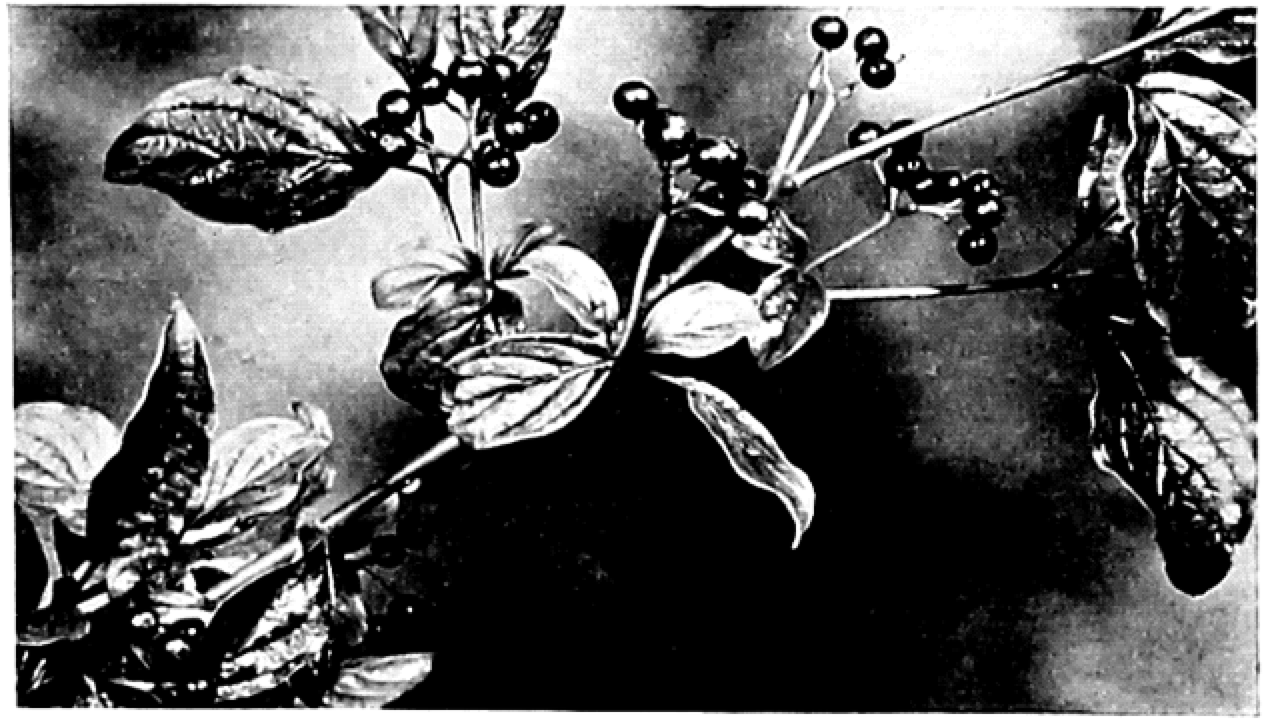
AUTUMN FRUITS



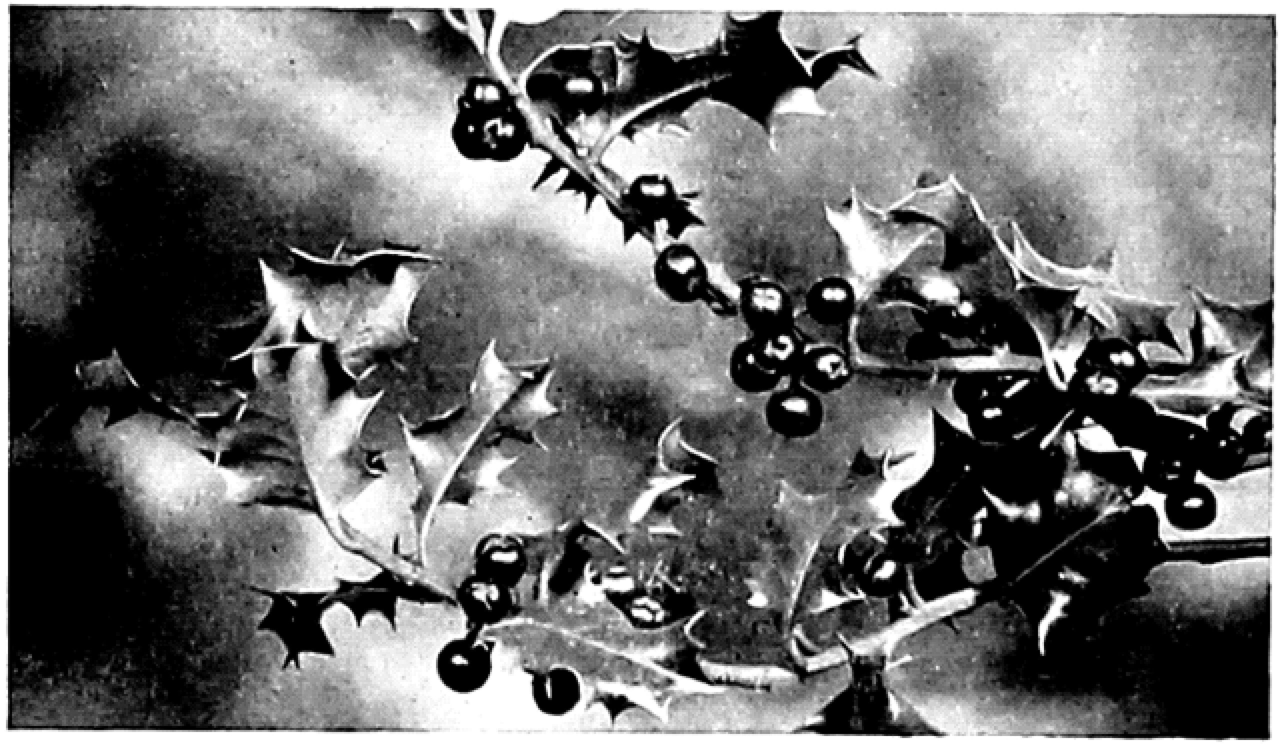
25 ELDER BERRIES



26 SLOES, FRUIT OF THE BLACKTHORN



27 BERRIES OF DOGWOOD



28 HOLLY BERRIES

BERRIES OF THE LESSER FOREST TREES

yet are local in distribution. Two evergreens, the Strawberry Tree and the Box, are rare as natives. The former occurs only near Killarney in south-west Ireland, whilst box is confined to small areas of chalk and limestone in southern England.

SHRUBS of various kinds are numerous, ranging from wild rose and bramble to the heather and bilberry of the moors. Some assist young trees, and hence the future forest, by protecting them from grazing animals in their earliest stages. Others compete with the tree seedlings. All are useful as indicators of the fertility of the soil.

SCOTS PINE (32, 48, 124). The Scots pine or fir (*Pinus sylvestris* Linn.), one of our few native conifers, formerly composed great areas of natural forest in Scotland. The Caledonian pine forest reached its best development in the eastern Highlands; farther west the heavier rainfall and the resulting peat bogs combined to check its growth. This native pine extended its natural range southwards into England, at least as far as the Trent; but it is generally held to have been introduced into the more southerly counties during recent centuries, though it has gained a footing as a " wild " tree on the heaths, from Kent to Dorset. An evergreen tree with blue-green needle-shaped leaves and a fissured bark, this pine is identified by its paired needles, symmetrical cone-shaped or oval cones, and its cylindrical, bluntly-pointed winter-buds. The flowers, each of one sex, appear in spring and are wind-pollinated. The cones take two years to ripen, and then release winged seeds which are wind-dispersed. The grown tree may be told apart from other conifers by its red-hued bark, which in the light of the setting sun provides a striking contrast with the blue-green foliage above.

The timber of Scots pine is strong and resinous. The sapwood is perishable out of doors unless creosoted, but the darker heartwood resists decay. Known as Red (or Yellow) deal, Scots pine timber enjoys an enormous demand for use in building construction, box-making, ship-building, and similar general uses. It is normally imported on a massive scale, under a wide range of merchant's marks and trade names, from Scandinavia and the Baltic lands. Home-grown timber is often of equal quality, but is seldom expertly graded and marketed.

Scots pine is widely planted on a commercial scale both in Britain and on the Continent. Tolerant as to soil, it demands full light, and is frequently used to nurse up less hardy trees. Its normal height growth is a foot a year, and it usually endures for at least a century. Only relics of the natural pine forest remain, but new plantations are continually being established throughout Britain.

YEW AND JUNIPER. The dark green, red-berried yew (*Taxus baccata* Linn.) forms interesting natural groves on the chalk downs of southern England, and also occurs wild in the New Forest. Once used for bows, it is no longer of value, and is not planted commercially (22).

The third native conifer is the sharp-needled, blue-berried juniper (*Juniperus communis* L.). Never more than a shrub, it occurs sporadically throughout the British Isles (114).

DISTRIBUTION AND DOMINANCE

The foregoing summary reveals the absence of many of our common trees from the woodlands of the north and west. Others again, do not occur naturally in Ireland. It is true that such trees as Wych elm and Scots pine occur only in the north, but on balance the south-east of England has a richer tree flora than other parts of Britain. Many of our native trees are at the natural limit of their range. They are nearly all European species and achieve better growth on that continent.

Only a few species grow with sufficient vigour to be regarded as *dominant* species forming the main constituent of pure or nearly pure woods. These are the two oaks, birches, and Scots pine, and in certain situations, alder, ash, and beech. These eight species are our main native timber trees. The others are of lesser importance, occurring casually in the woods, or grown for minor produce such as coppice material.

It follows that if only native trees were available, British forestry would have to limit its scope to the production of hardwoods which only attain first-rate growth in the south of the island, and to a single slow-growing softwood, the Scots pine. There are no native trees adapted to make the best use of the maritime climate of the west, for the native flora is derived almost entirely from the continental climatic zone of Europe.

The development of British forestry has therefore involved an ever-increasing use of imported trees, particularly conifers. Many of these occurred naturally in Britain in previous ages, but the accidents of geological and climatic history had removed them from our midst.

The scientific names cited in italics above embody certain recent changes. The more important of these are:—

OAK.	(*Quercus robur* L.) replaces (*Q. pedunculata* Ehrh.).
	(*Q. petraea* Liebe.) replaces (*Q. sessiliflora* Salis.).
BIRCH.	(*Betula pendula* Roth.) replaces (*B. alba* L.).
ELM.	(*Ulmus glabra* Huds.) replaces (*U. montana* With.).

Minor changes have also been made recently in the names of certain conifers mentioned in Chapter 4.

The following species of conifers, most of them of foreign origin, are represented in the photograph of seeds which appears as Fig. 6:—

Top row, winged seeds: Grecian fir, Noble fir, Scots pine, Corsican pine, Weymouth pine, Douglas fir.

Top row, unwinged seeds: Douglas fir.

Centre row, unwinged seeds: Scots pine, Corsican pine, Lodgepole pine, Sitka spruce, Norway spruce, Japanese larch, European larch, Lawson cypress, Nootka cypress.

Bottom row, winged seeds: Western Red cedar, Californian Big Tree, Californian Redwood.

CHAPTER 4

NEW TREES IN BRITAIN

The growing stock of Britain's forests has been increased in value and variety by a number of new trees introduced from most of the temperate regions of the world. Of the hundreds of tree species imported to these shores, the great majority have gone no further than botanic gardens and similar special collections. But a few score have come into general use for gardens and ornamental planting. Of these, a handful have been taken up by the commercial foresters of different times, and have been planted on an extensive scale. A few, such as larch, have become of the first importance as timber producers.

The gap between the introduction of a few specimen trees and the planting of a new species on a forest scale, can only be bridged by an enthusiastic planter willing to take the risk of an expensive failure. In theory, it would be possible for scientific foresters to assess the prospects of any potential timber tree by comparing its native soil and climate with those of Britain. In practice, the popularisation of new trees has in the past depended on the personal interest of some keen forester. Thus, the Dukes of Atholl scored a spectacular success with the larch, but William Cobbett failed to adapt the North American Locust Tree to the difficult British climate.

The greatest advances have been made in the introduction of conifers. Britain is naturally poor in such trees, and the new importations from similar maritime climatic zones have opened up new possibilities in range and rapidity of height growth and timber production. To understand such trees fully, it is necessary to study their growth, and the utilization of their timber, as it goes on in their natural homelands. But it does not follow that their behaviour in this country will invariably follow the same lines. In some instances, they escape old enemies in their new home, but in other cases they encounter fresh ones, or suffer more intense attack from the same pests.

In bringing in these new trees, the forester follows the lead already set by farmers and gardeners. Food plants as important as the potato and tomato are alien introductions which have enriched our diet. In the same way, larches, spruces, Sweet chestnut, and Douglas fir enhance the technical scope of home-grown timber production. Certain of these trees have been with us for so long, and have made themselves so much at home, that they run wild like native species. Another curious fact is the "reintroduction" of native species, such as Scots pine, by means of seed or plants imported from the Continent. Modern foresters pay much attention to the " strain " of seed imported, but in the past this factor was ignored, and the use of inferior races has occasionally given a bad name to otherwise desirable species.

It is simplest to review the new arrivals by reference to the countries whence they came. In this way, some idea may be gained of their relative adaptability to our variable climate; some find themselves at home only in the drier or warmer portions of Britain, as is the case with the Corsican pine; Others, such as Sitka spruce, revel in the heavy rainfall of Ireland, Wales, and the west of Scotland; a few, including Douglas fir, thrive in most or all districts, provided they have soil and shelter to their liking.

D

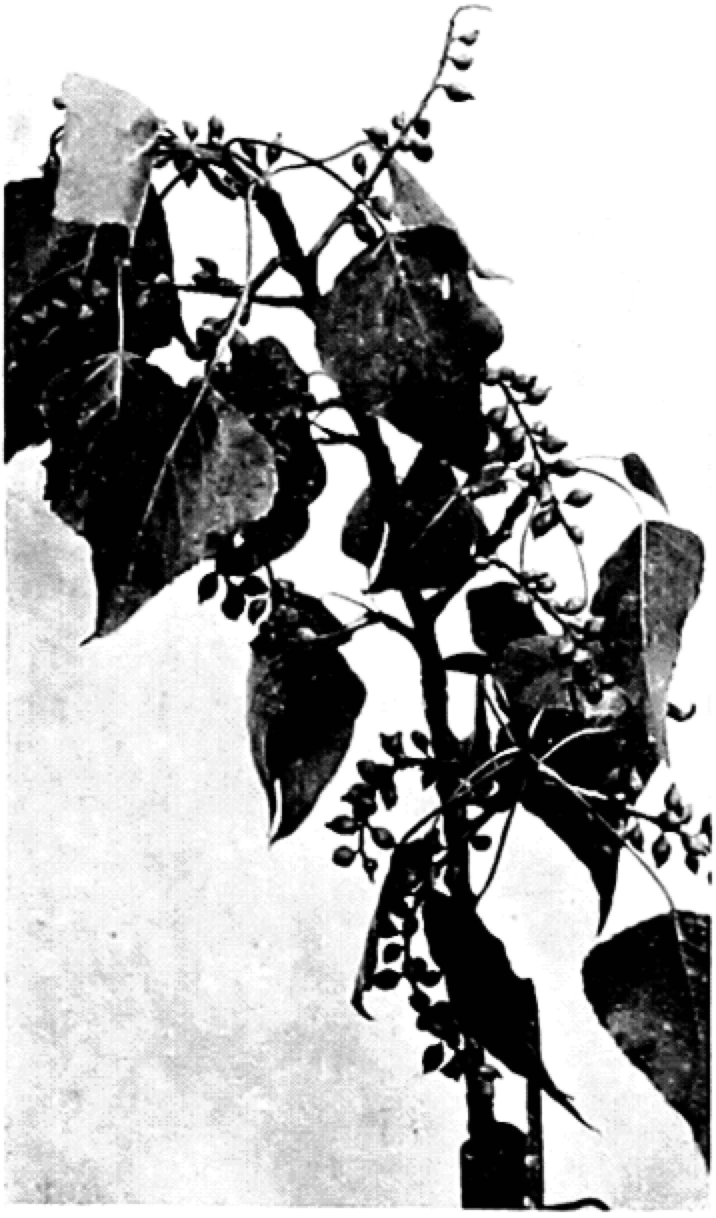
TREES FROM NORTHERN EUROPE

Most of the north European broadleaved trees are found amongst the native flora of Britain, and there have been only two important introductions, both of them maples. The SYCAMORE or Great maple (*Acer pseudoplatanus* Linn.) (181), known as the " Plane " in Scotland, is native to the Central European hills. The NORWAY MAPLE (*A. platanoides* L.) is found in the plains further north. Both have lobed leaves, which are rounded in the sycamore, but sharply pointed in the Norway maple; both bear paired winged seeds. Their timbers are moderately hard, pale in colour, and can be worked to a fine finish. They are used for flooring, furniture, table-ware and rollers. Sycamore is the commoner tree of the two, and is frequently planted to form windbreaks; though it requires sheltered conditions in youth, when mature it is very windfirm, Its seeds travel far, and naturally-sown thickets of young sycamore commonly occur near the older trees.

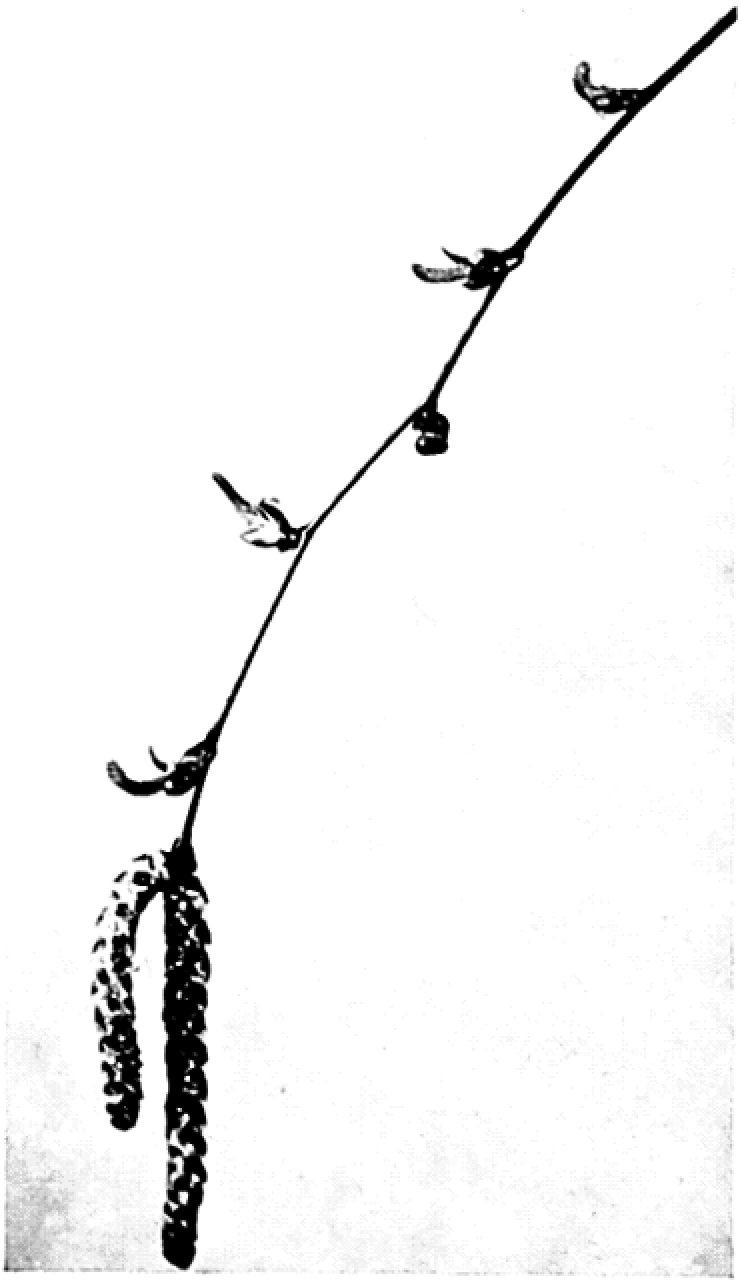
NORWAY SPRUCE (*Picea excelsa* Link., *P. abies* K.) (39, 164, 169). The Norway or Common spruce has a wide distribution in eastern and northern Europe, reaching the Atlantic shores in Norway. Before the Ice Ages it was found in Britain, but all our present-day spruces result from importations in the last few centuries. This spruce is familiar to all as the Christmas Tree. It is pyramidal in form, and the single needles leave rough woody pegs on the stems when they fall. The cones are long and pendulous, the bark smooth, and the root system frequently shallow, with buttresses at the base of the trunk. The timber is imported as White deal; being soft, white, and only slightly resinous, it is suitable for indoor furnishing and box-making, but it is not durable out of doors. It is employed in plywood and paper-pulp manufacture, being one of Europe's most important timbers.

The Norway spruce is now one of the most widely planted trees in Britain. For its finest development it requires a deep, moist but well-drained soil, and shelter from the south-west winds. On the whole it adapts itself well to a wide range of situations, its principal dislikes being the dry sandy soils of our English lowlands, and the blast of the prevailing winds in the uplands of the west. It is also peculiarly sensitive to the presence of heather in the vegetation, seldom thriving well where that plant is abundant. But the forester finds it especially useful on damp grassy or rushy lands in the hills, and it is also used for underplanting. Although slow-growing in early youth, it speeds up later on, and when mature produces a heavy crop of timber.

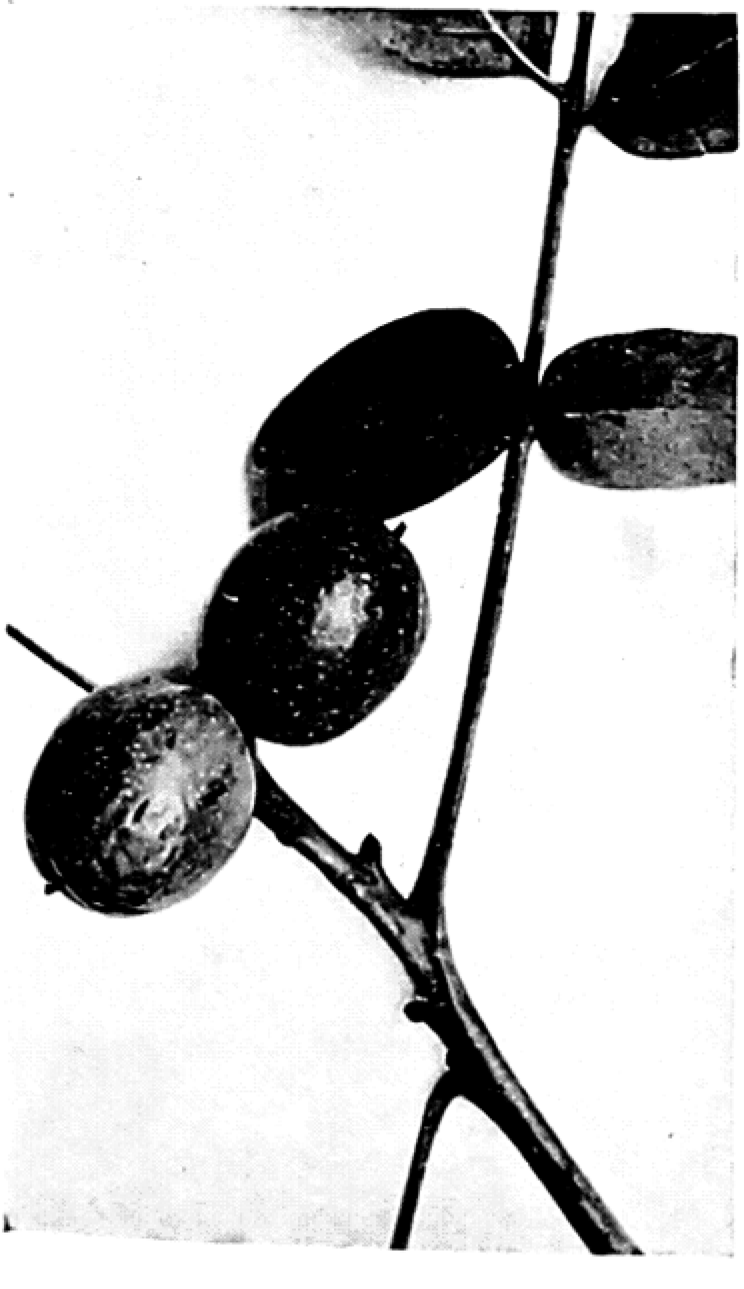
EUROPEAN LARCH (*Larix decidua* Miller) (35, 113, 118). One of the most attractive of conifers, the larch is distinguished by its emerald-green leaf-tassels and rose-red flowers in spring, and its grass-green clustered needles which turn to straw-gold as they fall in autumn. For the larch is deciduous. It is an Alpine tree, native to the high mountains of central Europe, so it is not surprising that seed from the lower valleys gives better crops in Britain than do the high altitude strains. The story of its introduction in 1725 reads like a fairy tale. The first specimen is said to have come from Italy, and was grown at first in a hothouse. When it was found to be hardy, the interest of the second Duke of Atholl led to extensive plantings being made in the Perthshire highlands around Dunkeld (171). Here it throve so well that it has since been planted throughout these islands. The larch is especially valuable for estate work, as stakes of small sizes are strong and durable, as is the mature timber also. Its timber has so far commanded a higher price than



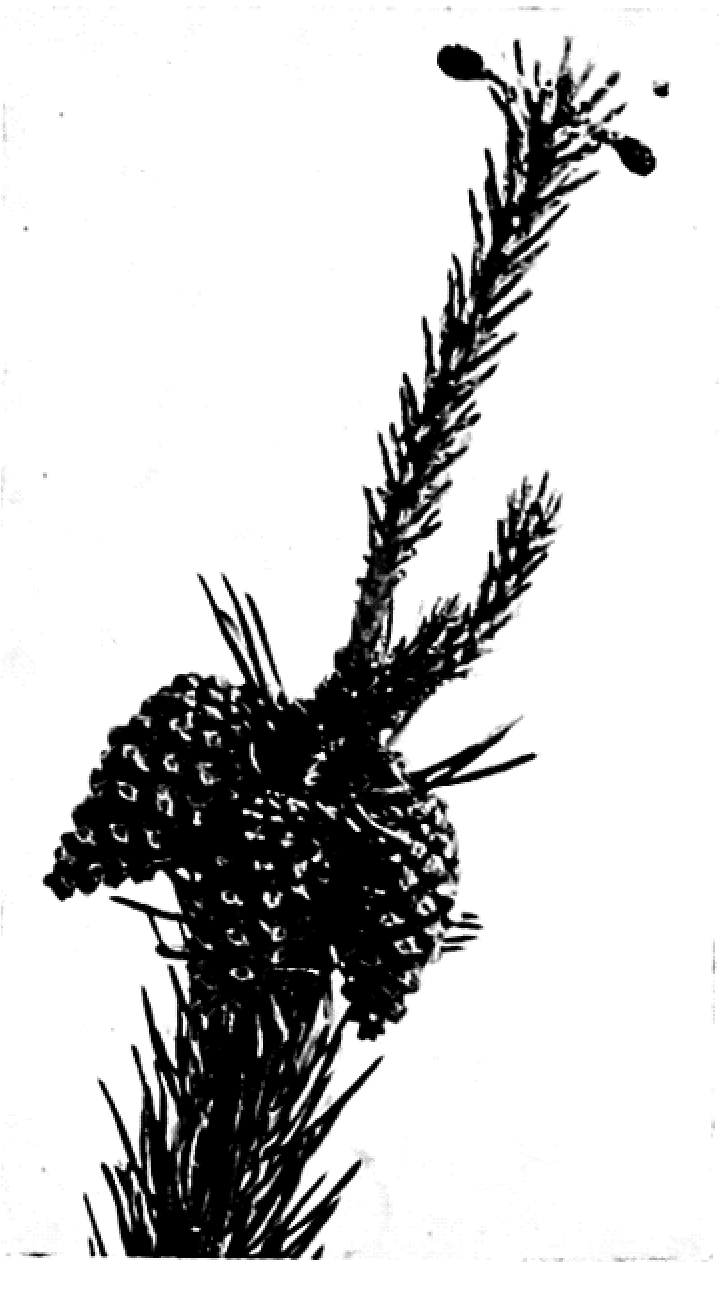
29 FRUITS OF FEMALE BLACK POPLAR, MAY



30 MALE AND FEMALE CATKINS OF BIRCH, APRIL

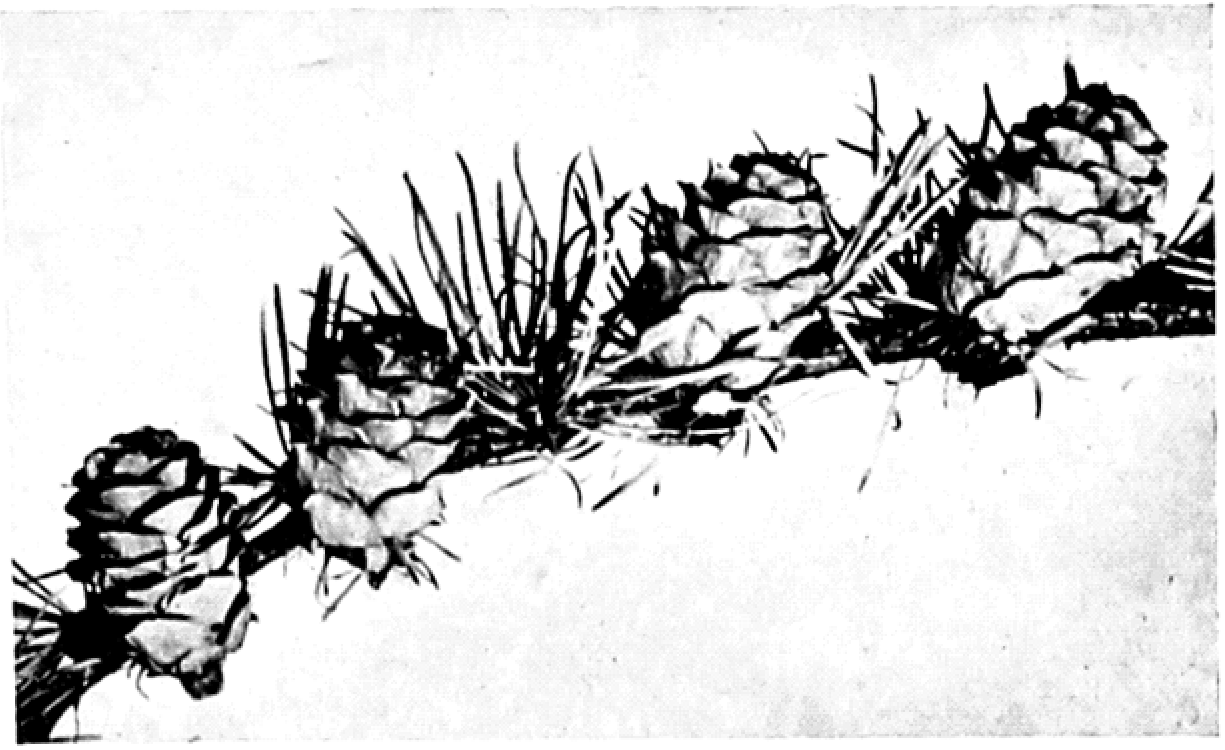


31 RIPENING WALNUTS, AUGUST

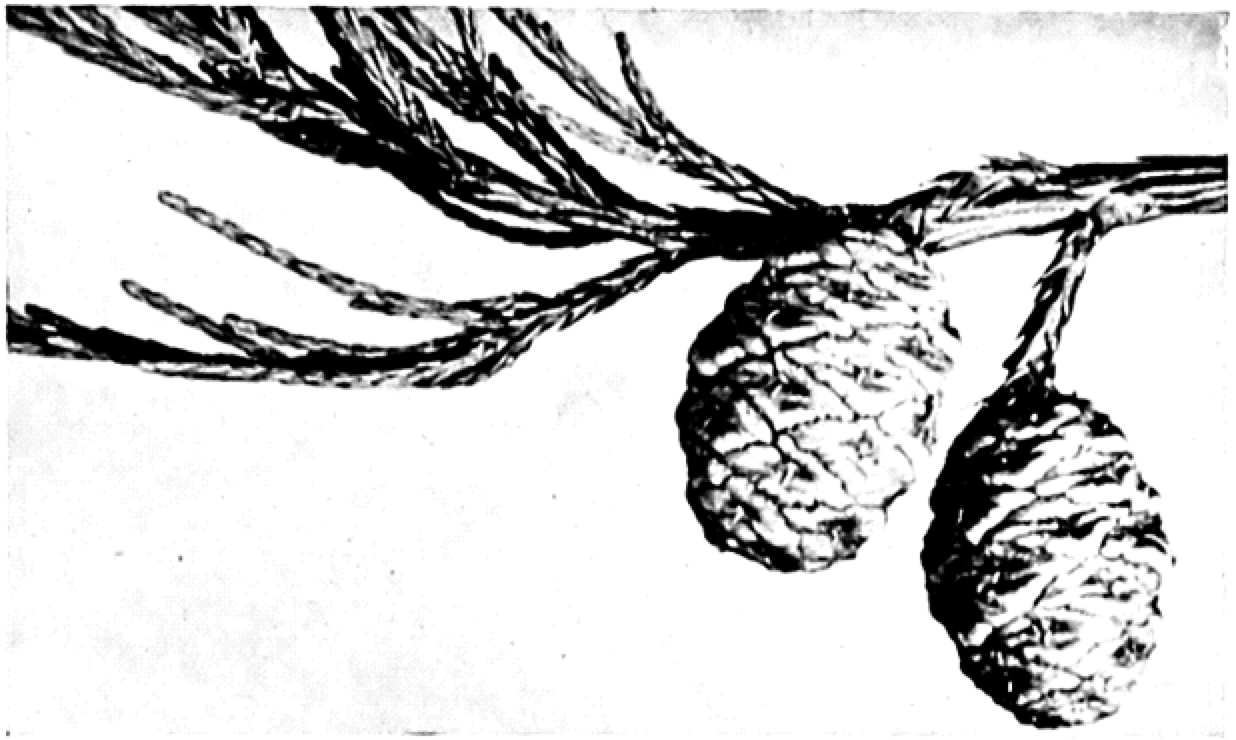


32 FEMALE FLOWERS AND ONE-YEAR-OLD CONES OF SCOTS PINE, JUNE

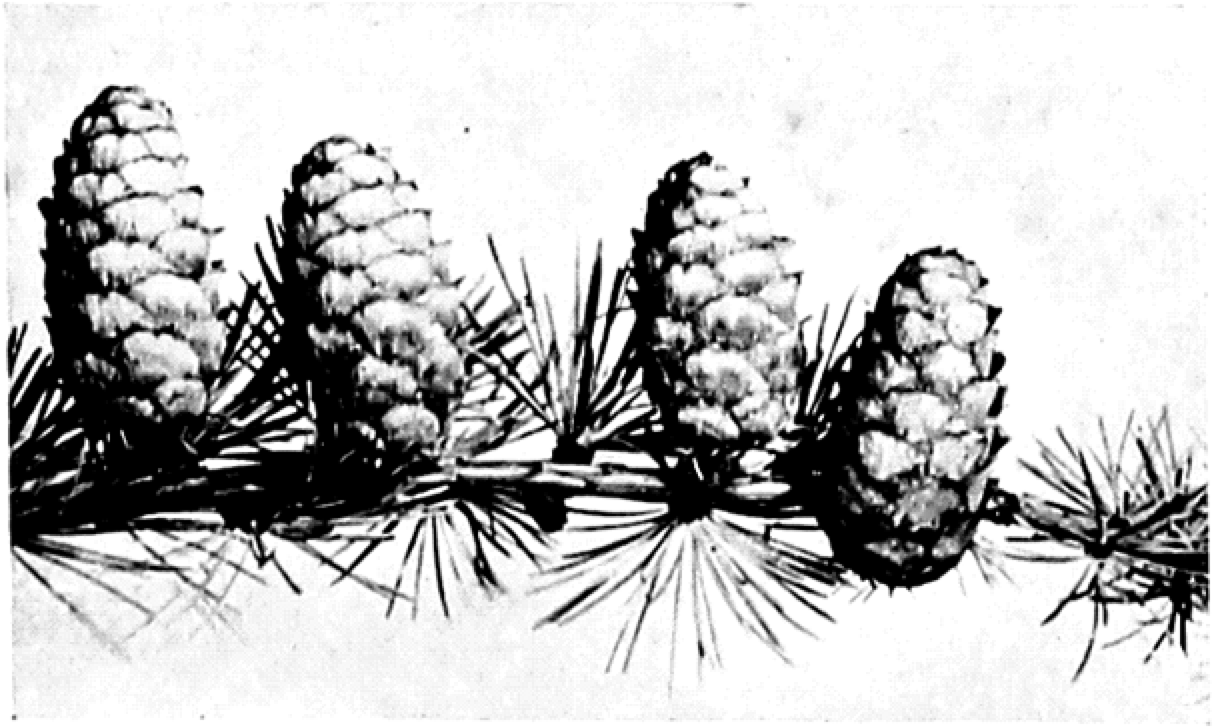
QUAINT FLOWERS AND FRUITS OF FOREST TREES



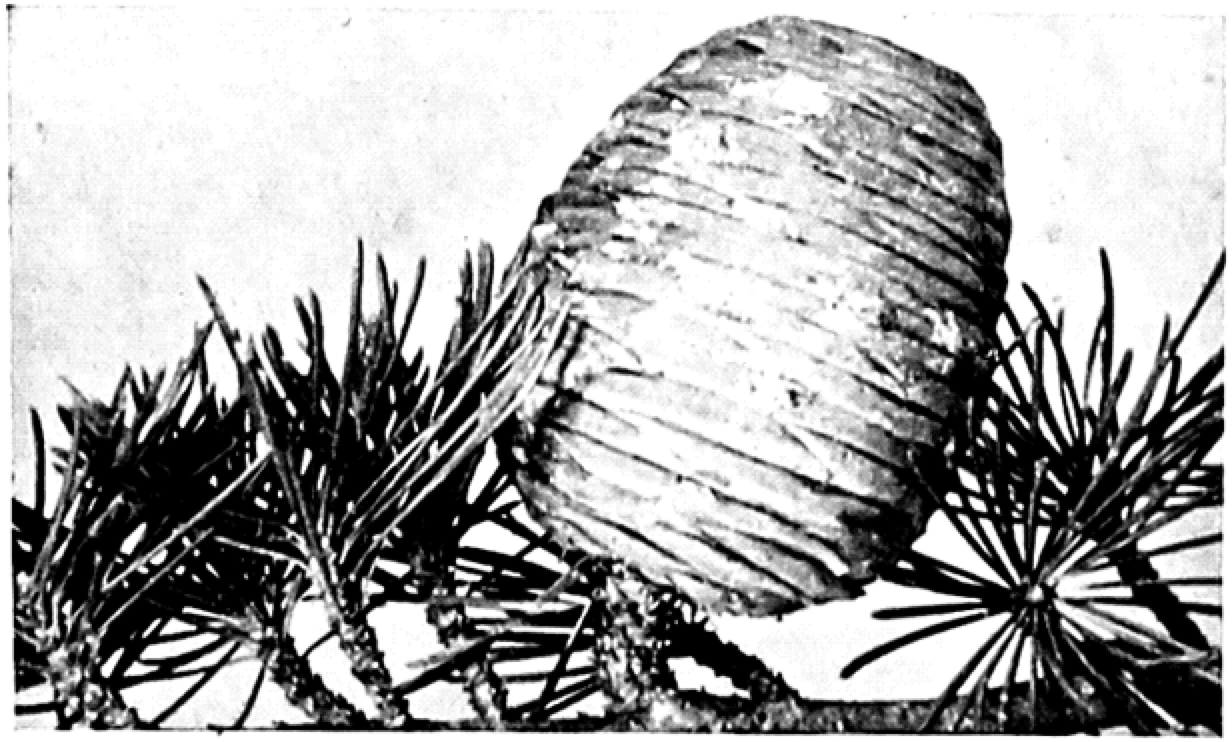
33 JAPANESE LARCH, *LARIX LEPTOLEPIS*



34 CALIFORNIAN BIG TREE, *SEQUOIA GIGANTEA*



35 EUROPEAN LARCH, *LARIX DECIDUA*



36 CEDAR OF LEBANON, *CEDRUS LIBANI*

CONES AND FOLIAGE OF INTRODUCED CONIFERS that of other home-grown conifers. In youth, larch is frequently attacked by the Larch Canker Fungus (*Dasyscypha willkommi* R. Hartig) which sometimes merely weakens or damages the tree without killing it. But if the larch has been planted on an unsuitable or very frosty site the canker may become a virulent parasite, killing the trees wholesale. Larch is a light-demanding tree, requiring good soil, but wherever it thrives it grows rapidly and matures in little more than seventy years.

SILVER FIR (*Abies alba* Miller) (115, 166). A handsome tree with wide-spreading branches, the European Silver fir may be recognized by the flattened layout of its notch-tipped, solitary needles, which leave a flat round scar when they fall. Its large cones are upright and take two years to ripen; their scales then fall away, releasing the winged seeds, and leaving a slender erect central stalk. Native to central Europe, it thrives well in eastern England, but is frost-tender and difficult to raise, although self-sown seedlings are common where there is sufficient shelter. The common Silver fir is liable to attack by a minute leaf-sucking insect (*Adelges*); this being one of the reasons why the British forester is chary of planting it on any large scale, despite the example of the magnificent specimen trees that have escaped attack and stand as landmarks on many of our country estates.

MEDITERRANEAN TREES

Despite obvious climatic differences, some of the trees from the shores of the Mediterranean and its satellite seas thrive remarkably well in Britain, following the general rule that maritime trees succeed better with us than do continental species.

Of broadleaves, the most important is the SWEET CHESTNUT (*Castanea sativa* Miller) (110, 116), probably introduced by the Romans for the sake of its edible nuts, and now naturalised in southern England. Distinguished by its long oval leaves, which have a jagged edge, it has stout angular twigs, and bears masses of catkins in August. These are followed by large brown nuts in spiny husks. On good ground it forms a fine upstanding tree a hundred feet or more in height. It develops great girth and may last for centuries; in old trees the bark becomes deeply fissured in a spiral pattern.

Chestnut timber resembles oak, but large trees frequently develop faults known as *shakes*, which lead to waste in the sawing up. It is sometimes substituted for oak, but the grain is not so handsome. Unlike oak, its sapwood is fairly durable, so that small poles and stakes may be used in contact with the ground. This property is put to good use in the Kentish hopfields, which absorb large quantities of coppice chestnut poles. Still smaller poles are used for making cleft-pale fencing. Chestnut is occasionally planted for timber, as well as being a coppice crop.

WALNUT (*Juglans regia* Linn.) hails from Asia Minor, and was introduced in the Middle Ages for the sake of its fruit. Although its wood is greatly valued for decorative work and gun-stocks, it is not widely grown as a timber tree, succeeding only in favoured localities.

Other well-known trees from this area which are often met with in parks and gardens, but rarely in the forest, are the Horse chestnut (10), noted for its spires of white or pink flowers; the laburnum with its hanging chains of golden blossom; the sweet-fruited mulberry; and the magnificent plane, with its lobed leaves, mottled bark, and ball-shaped fruits.

THE CORSICAN PINE (*Pinus laricio* Poir.) (1,121) is the most important conifer introduced from the Mediterranean zone. It resembles the native Scots pine, being distinguished by its sharply pointed winter buds and a curious twist in its greener needles. As a young tree it is a little difficult to raise, and grows slowly. Later on, it often overtakes the Scots pine in height growth, also surpassing it in girth, and proves the more rapid timber producer. Adaptable as to soil, it thrives on barren sands or shallow-soiled chalk land, and is of great value in the afforestation of waste lands in low rainfall areas. It is probably a distinct species from *Pinus nigra.*

The allied AUSTRIAN PINE (*Pinus nigra* var. *austriaca* A. & S.), distinguished from the foregoing by its *straight* needles, has also been widely planted. It is a continental species, and is remarkable for slow, irregular, much-branched growth, which unfits it for timber production. It will grow in the most exposed situations, on chalk or poor sandy soils, and is useful as a windbreak.

Another Mediterranean conifer commonly planted in former years in the south-west of England is the MARITIME PINE (*Pinus pinaster* Aiton), distinguished by its very long, tough, paired needles, reflexed bud-scales and enormous oblique cones (41). It is a tree of rapid growth, but most of the specimens planted in Britain have a tendency to crooked stems, whilst their wood, though resinous, is wide-ringed, soft, and weak. It appears probable that they are of an inferior race or strain, for in Portugal and in the Landes forests of south-western France, this same tree is highly esteemed as a producer of sound, strong, and close-grained timber, suitable for good carpentry and general joinery. The growing trees there are tapped for resin and turpentine, the rougher branchwood is converted into paper pulp, and the smaller trees that are removed as thinnings are shipped in quantities to the South Wales coalfield in the form of pit-props. This tree might give good results in the west of Britain, if a satisfactory strain could be secured.

Ornamental conifers from the Mediterranean region include the Spanish, Grecian, and Numidian Silver firs; the Servian and Oriental spruces; the Italian cypress; the Macedonian pine (42); and the majestic cedars. Both the Atlas or Atlantic cedar from North Africa, and the cedar of Lebanon (36), famed from biblical times for the excellence of its fragrant timber, thrive with us as picturesque parkland trees.

INDIAN TREES

The great height of the Himalayas compensates for their southerly latitude to such an extent that certain of their trees are quite at home in the British climate. Larches, spruces, pines, and Silver firs have all been introduced for ornamental planting. the DEODAR or Indian cedar (*Cedrus deodara* Loudon) (120), an important timber tree of the western Himalayas, promises well in British plantations, producing an attractive and durable, though somewhat oily, timber at a satisfactory rate of growth. It is a beautiful tree, with needles borne in tufts like a larch, but persistent and evergreen. The erect, barrel-shaped cones are distinctive.

Certain Chinese trees have been introduced on a small scale, including the decorative Maidenhair Tree or Ginkgo. China has many conifers, but they are little known here as yet.

JAPANESE TREES

The climate of Japan resembles our own in most of the factors that influence tree growth. It is a country rich in conifers, including bizarre forms extinct elsewhere, such as the Japanese Umbrella Tree and the Japanese cedar (*Cryptomeria*) (7). The JAPANESE LARCH (*Larix leptolepis* Gord.) (33) has become one of our leading plantation trees. A maritime species, better adapted to British climatic conditions than the alpine European larch, it outgrows that species and rapidly produces useful timber of moderate quality and fair durability. Two feet a year is an average rate of height growth during youth. Its appearance is not unattractive, with red-barked twigs, blue-green needles, and reflexed cone-scales. Rapidly-growing specimens assume a spiral form in their leading shoots, but straighten out later. It is resistant to fire damage and may indeed serve as a fire-break, has few natural enemies, and is adaptable as to soil.

Japanese pines, spruces, and Silver firs have so far only been employed in small-scale plantings; but certain of them might possibly repeat the success of the larch, for the same climatic reasons.

EASTERN NORTH AMERICA

The early settlers on the eastern or Atlantic seaboard of North America sent home a wide variety of the trees which they found there. The more remarkable of these gained a permanent place in the gardens and parks of Britain. But despite large scale attempts with several species, none of these trees is now used in our afforestation. Climatic causes appear responsible for this. The mild British winter, followed by uncertain late frosts in spring, nips the eastern American trees in the bud, and weakens them year after year.

The Tulip Tree, with its quaint saddle-shaped leaves and globular blossom, we have adopted for ornamental purposes. The same role is now allotted to the LOCUST, also known as the Robinia or False Acacia (*Robinia pseudacacia* Linn.). But early in the nineteenth century William Cobbett, essayist and agriculturist, launched a propaganda campaign to popularise it for general planting. Claiming that it would produce timber of exceptional utility with great rapidity, he induced landowners to plant it by the thousand. Here and there it throve, but its growth proved altogether unexceptional, and woodworkers were unenthusiastic about its toughish timber. It is now more valued for its chains of white sweet-pea-shaped flowers. Though Cobbett failed to revolutionise our forestry in the way he hoped, he did prove for all time that no single tree is likely to succeed equally well throughout Britain's varied countryside, nor will any one timber meet all the needs of modern industry.

WEYMOUTH PINE (*Pinus strobus* Linn.) is a five-needled species with distinctive long narrow banana-shaped cones. In the eastern United States, where it is called the White pine, it grows rapidly into a beautiful tree with easily worked timber highly favoured for building construction. But in Britain its growth is adversely affected by insects (*Adelges*) and fungi, including a rust disease known as *Cronartium ribicola* Dietr. Successful only in a few localities, it is no longer planted as a forest crop.

SWAMP CYPRESS (*Taxodium distichum* Linn.), a deciduous conifer with delicately divided leaf sprays, is an impressive ornamental tree from Florida, where it yields useful timber in the swamps (7).

WESTERN NORTH AMERICA, OREGON AND BRITISH COLUMBIA

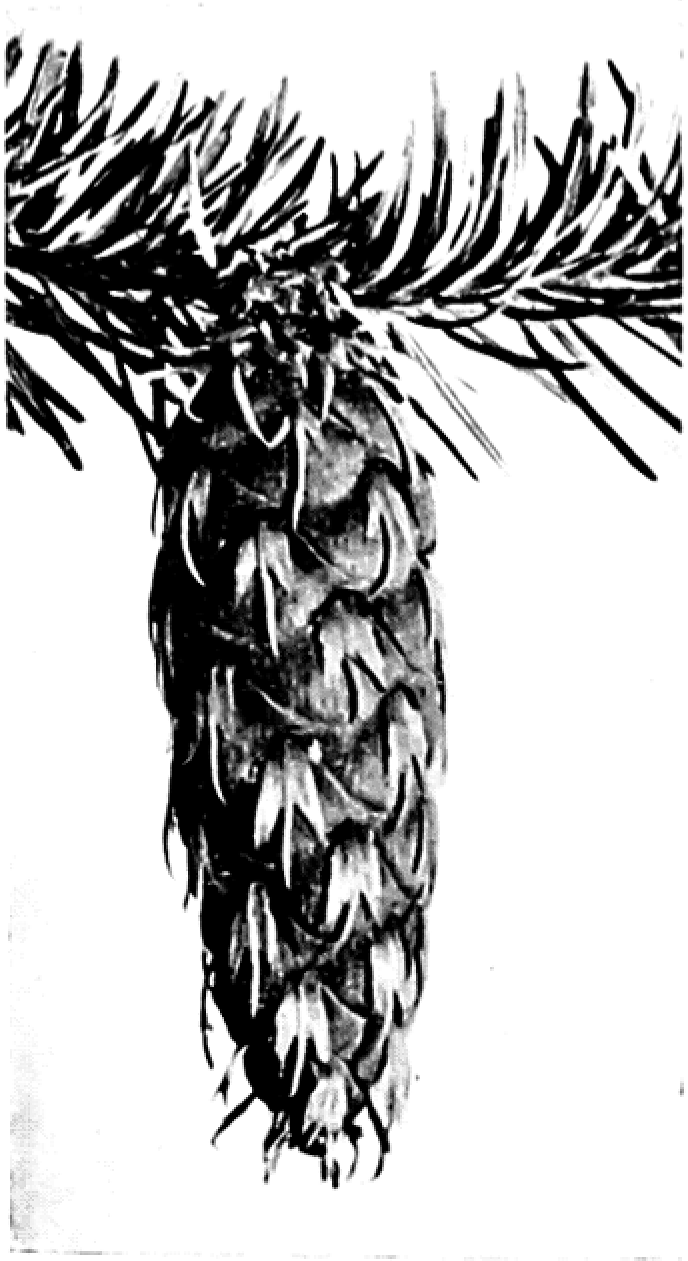
Geographically and climatically, the region around Vancouver and Seattle forms a close counterpart of the British Isles. Lying in the same latitude, on the western side of a continent, it enjoys the same mild winters and cool summers, with rainfall distributed throughout the year. Thanks to its remoteness, its exploration, both botanically and commercially, was delayed until the nineteenth century. Now its vast forests are one of the world's primary timber-producing regions, and it has greatly enriched Britain's store of forest trees.

DOUGLAS FIR (*Pseudotsuga taxifolia* Britton) (37, 122, 167) is the dominant tree over vast areas of this forest zone. One of the tallest trees in the world, scaling up to 300 feet, it yields a great bulk of useful timber; the trade name of this wood was formerly Oregon " Pine," but the misnomer is now being corrected by the growing use of its proper name of Douglas fir. It takes its name from the Scottish botanist, David Douglas, who first sent its seeds to Britain in 1828; since then it has been widely planted throughout the country. It may be recognized by its narrow, pointed, brown, and papery-scaled winter buds, and by its hanging cones, each scale of which bears a three-pointed bract. Its foliage is fragrant, and it is a magnificent tree, designed on the grand scale. Often growing more than two feet in each season, it outgrows most other kinds. How tall it will yet grow here, nobody knows. Many trees exceed the hundred-foot mark, and one has passed 175 feet, being the tallest tree recorded in these islands. Growth in volume is equally impressive. Single trees contain from two to six *hundred* cubic feet of timber after less than eighty years growth. The Douglas fir is one of several western American species that open up entirely new possibilities for home timber production, having rates of increase in timber volume that are far higher than those of any of our native trees. It requires moderately good soil, and is greatly helped by slight shelter in youth. It sets fertile seed here, and self-sown seedlings are frequently found near old trees.

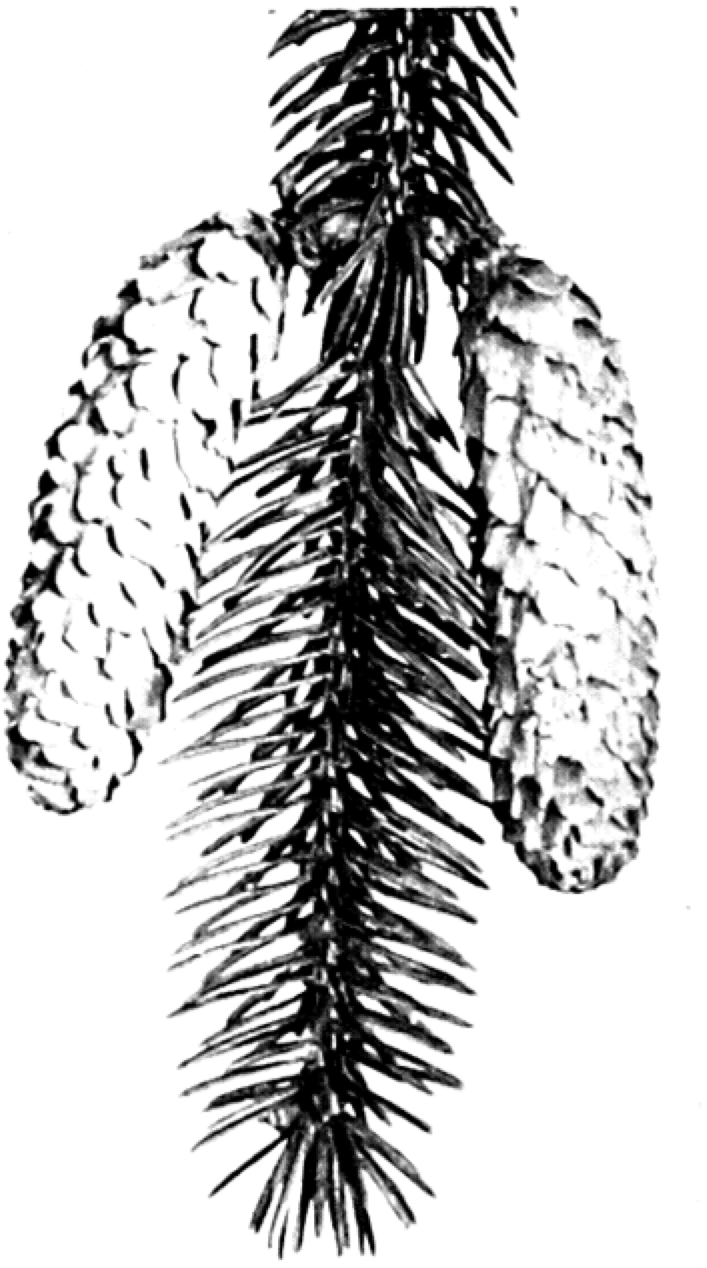
LAWSON CYPRESS (*Chamaecyparis lawsoniana* Sud.). Commonly grown in gardens, this tree has its scale-like leaves compressed along flattened branchlets forming fern-like, decorative, evergreen foliage which is curiously fragrant. The little cones are globular. In the forest it forms an erect trunk of durable timber, also known as Oregon or Port Orford " cedar." It grows rapidly on favourable sites, bears shade well, and has been used on a small scale for forest planting and underplanting. NOOTKA CYPRESS (*C. nootkatensis* Lamb.) is closely allied (45).

WESTERN RED CEDAR (*Thuya plicata* D. Don.) (46, 123), known also as the Tree of Life or *Arbor vitae*, has foliage like the foregoing but its cones are composed of long scales, lax and tapering to a point. It promises well in British plantations, besides being a favourite subject for hedges and ornamental planting. Its durable, greyish wood is surprisingly light in proportion to its size and strength; it is the " cedar " of cedarwood roof-shingles.

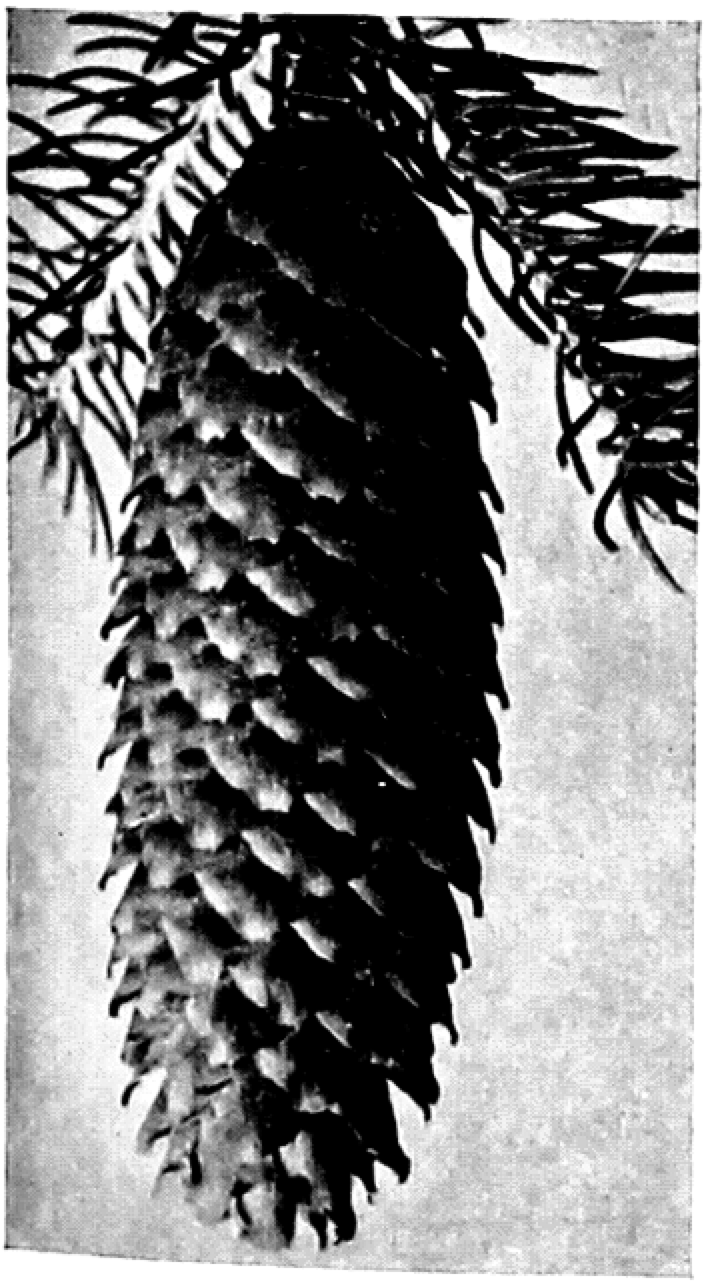
WESTERN HEMLOCK (*Tsuga heterophylla* Sargent) (7, 44) is a beautiful conifer with gracefully drooping branches, and a multitude of minute leaves of irregular lengths. It bears tiny buds and small tapering cones. A shade-bearing conifer requiring shelter in youth, it is used for underplanting old woods,



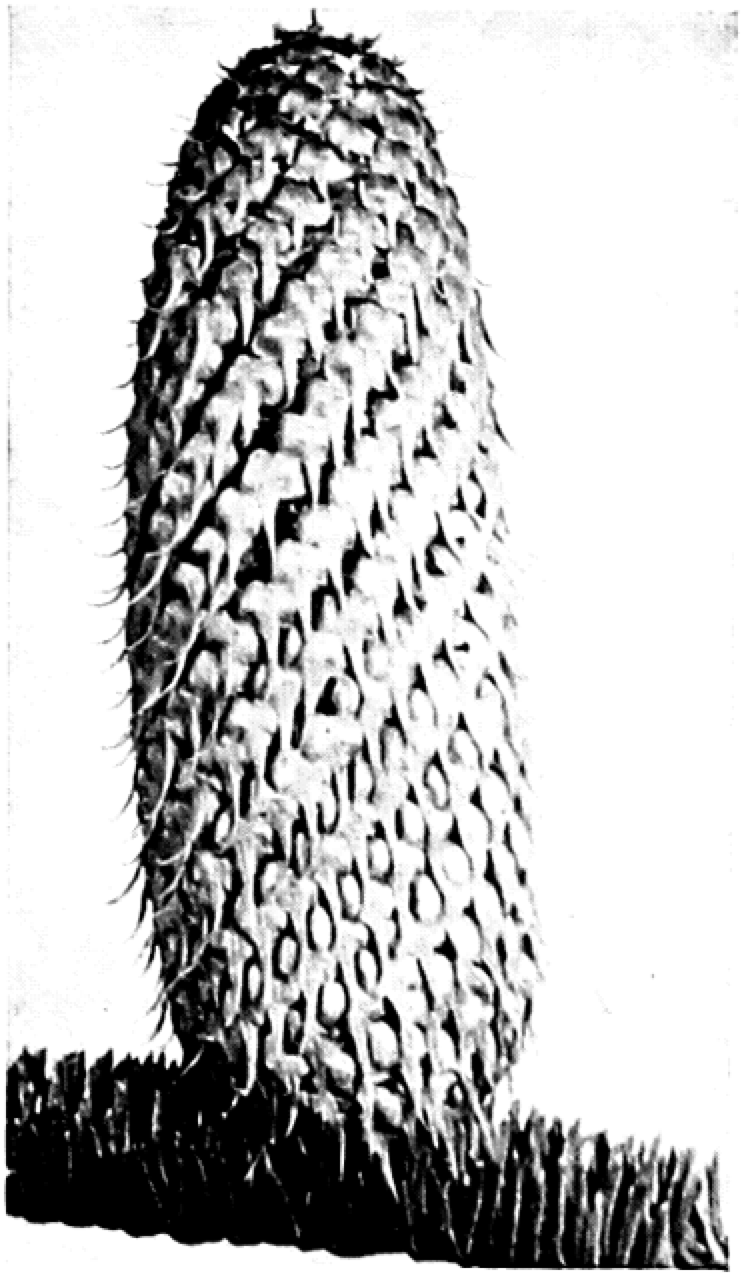
37 DOUGLAS FIR, *PSEUDOTSUGA TAXIFOLIA*



38 SITKA SPRUCE, *PICEA SITCHENSIS*

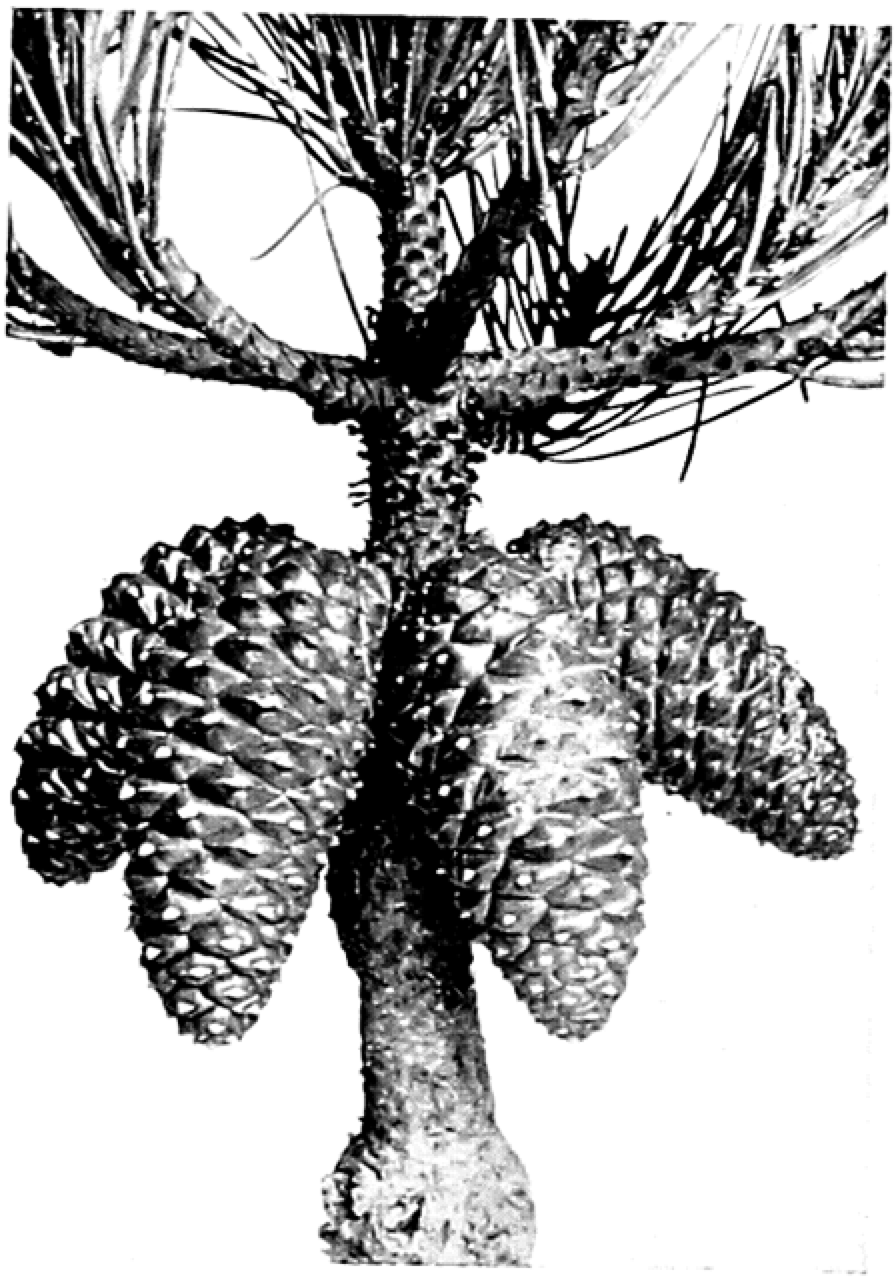


39 NORWAY SPRUCE, *PICEA EXCELSA*

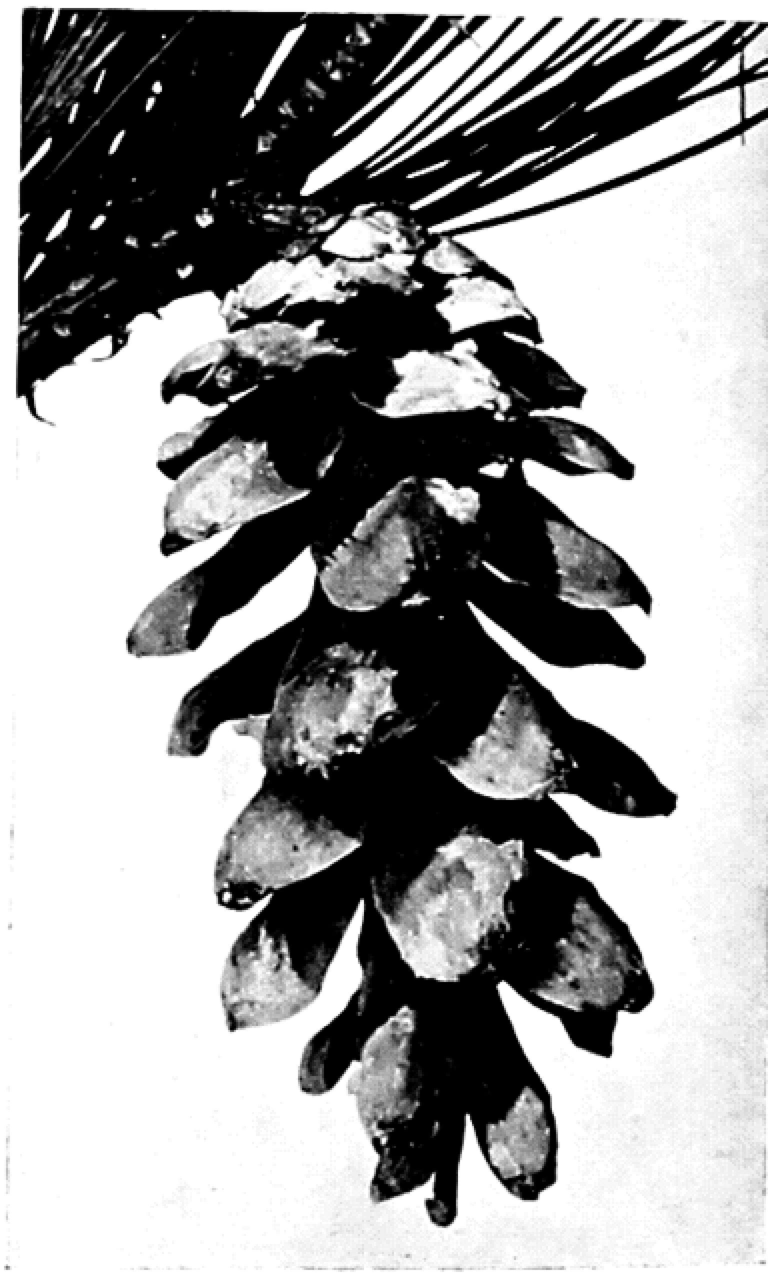


40 NOBLE FIR, *ABIES NOBILIS*

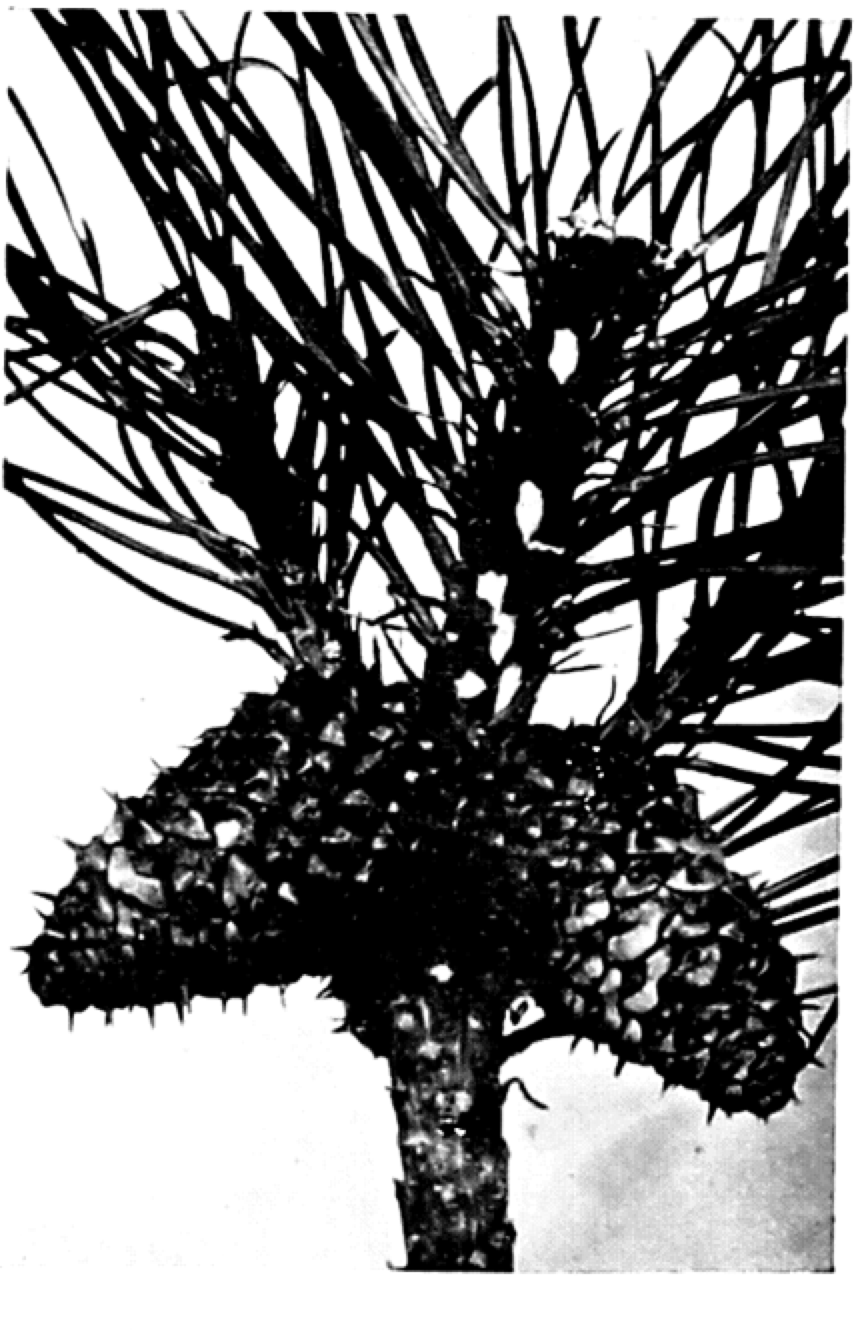
DROOPING AND UPRIGHT CONES OF FIRS AND SPRUCES



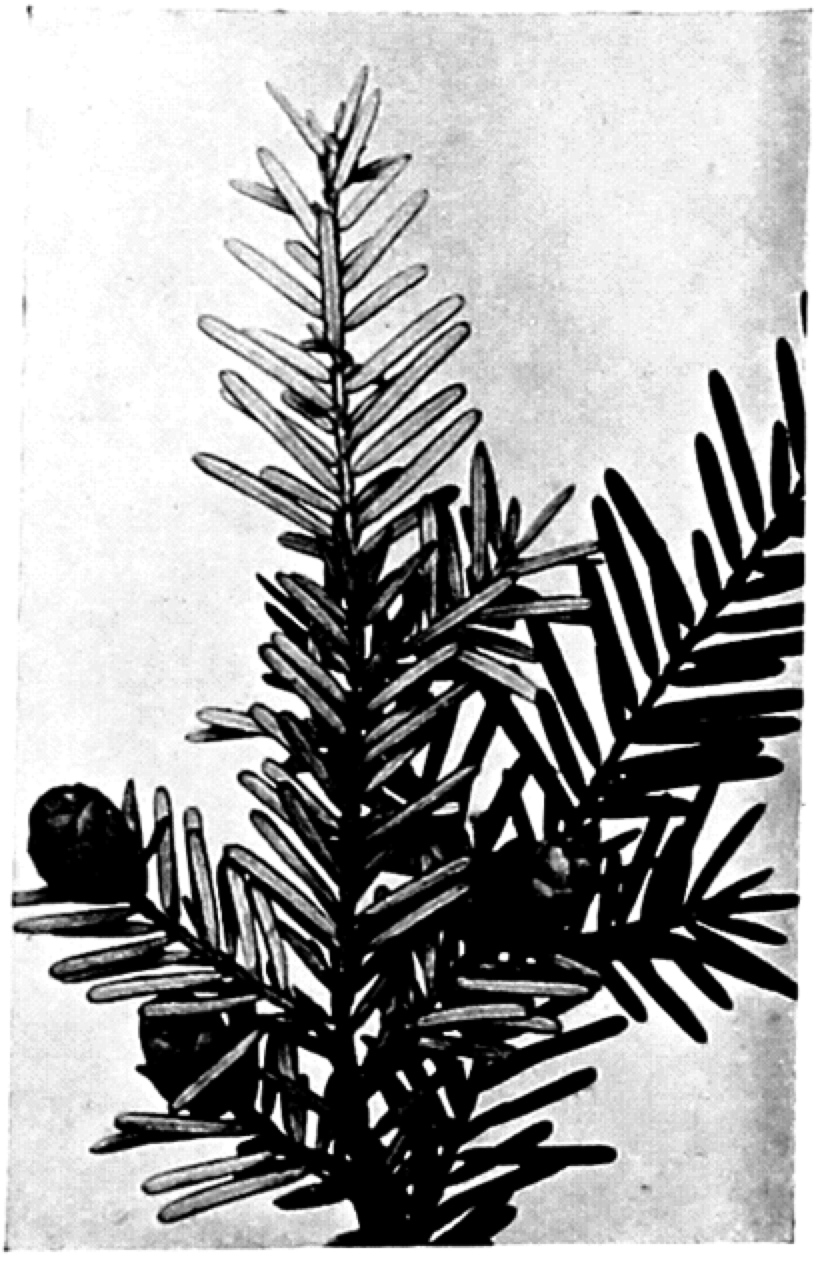
41 MARITIME PINE, *PINUS PINASTER*



42 MACEDONIAN PINE, *PINUS PEUKE*



43 LODGE-POLE PINE, *PINUS CONTORTA*



44 WESTERN HEMLOCK, *TSUGA HETEROPHYLLA*

CONES OF PINES AND HEMLOCK

and on a small scale as a pure crop. Its timber is suitable for building construction, box making, and paper pulp.

The four trees mentioned above are of genera unknown or rare as natives of Europe. Varieties of more familiar trees have also been brought from this region and are frequently found to thrive better in Britain than their continental European counterparts. The chief of these is the SITKA SPRUCE (*Picea sitchensis* Carr.) (38), distinguished from the Norway spruce by its silvery, blue-green, sharp-pointed needles, and cones with crinkly-edged scales. A larger tree, of more rapid growth, it thrives better in most British situations, especially in the high rainfall areas of the west.

The Sitka spruce is unquestionably the most important and valuable of all additions to our stock of forest trees. During the past twenty years it has played a steadily growing part in the afforestation of the hill lands of Ireland, Wales, northern England, and the west of Scotland. Whilst its general requirements in the matter of soil and climate resemble those of the Norway spruce, Sitka is much more resistant to wind blast—a very important factor in these wind-swept islands. Moreover, Sitka will thrive on many soils where its Norwegian cousin can scarcely maintain a struggling existence. It is not too much to say that the introduction of Sitka spruce has brought a vast new extent of British moorlands within the scope of economic afforestation.

GRANDIS FIR (*Abies grandis* Lindley) and NOBILIS FIR (*Abies nobilis* Lindley) (40) are now used in our forests in place of the European Silver fir, again proving healthier and quicker growers.

LODGEPOLE PINE (*Pinus contorta* var. *murrayana* Engel) (43) may succeed better than our native pine in the wetter areas of the west. It is useful as a " nurse " for Sitka spruce on poor peat soils in the west of Scotland.

Of hardwoods, the OREGON BALSAM POPLAR (*Populus trichocarpa* Torrey and Gray), not only grows faster than do most European species but has also yielded interesting hybrids when crossed with other kinds. Unfortunately it is apt to be damaged by canker in many localities, and is therefore not widely planted.

CALIFORNIA

Climatically the American equivalent of the European Mediterranean zone, California has yielded several trees hardy in Britain. MONTEREY PINE (*Pinus radiata* D. Don.) is a three-needled species of very rapid growth. MONTEREY CYPRESS (*Cupressus macrocarpa* Hartweg) (47) differs from Lawson cypress, both in the radial arrangement of leaves and branchlets, and in the size of its cones, which are larger and conspicuous. It is a vigorous grower. Hardy only in the south and west, both the above species are used for windbreaks and ornamental planting rather than for forest work.

INCENSE CEDAR (*Libocedrus decurrens* Torrey) is another Californian conifer that flourishes in many parts of Britain. It has an erect columnar habit, and so far has only been used for landscape planting, although its durable, fragrant timber is highly valued in North America.

But the greatest trees of California are the sequoias, the tallest and largest trees in the world. There lies the sole surviving home of the two existing species, which were formerly widespread.

The BIG TREE OF BIG WOOD (*Sequoia gigantea* Decaisne) (7, 34), with scale-like leaves set spirally on its branchlets, is the greater in bulk when mature. 300

feet tall, 30 feet in diameter, with a volume of 50,000 cubic feet and a weight of 800 tons, it may attain an age of 3,000 years. A continental species of limited distribution, it was not discovered until 1841. It thrives in Britain, succeeding best in sheltered situations, and is much used for ornamental work; of rapid growth, specimen trees have already risen to 150 feet in height only 70 years after planting. Its conical shape when open-grown is very distinctive.

CALIFORNIAN REDWOOD (*S. sempervirens* Endl.) (7) is the more useful timber producer, and as a wild tree extends over a larger area. Its leaves are flattened and set in one plane on slender branchlets, and though of less bulk, it attains greater height than the Big Tree, up to 364 feet. Although the more maritime species, it is less well adapted to the British climate, being frost tender and difficult to establish, but some interesting experimental plantings have been made. Both the redwoods have a soft and fibrous bark, and globular cones.

THE SOUTHERN HEMISPHERE

So far the temperate zone of the southern hemisphere has yielded no trees of importance in British forest planting. The Monkey Puzzle or Chile Pine is a bizarre tree used in garden planting, and a Chilean beech (*Nothofagus*) has been tried experimentally. The Kauri pines of New Zealand are known to be hardy in some parts of these islands, but have not been planted under forest conditions. Certain Australian Eucalyptus trees also thrive here, but only in sheltered localities of the south and west.

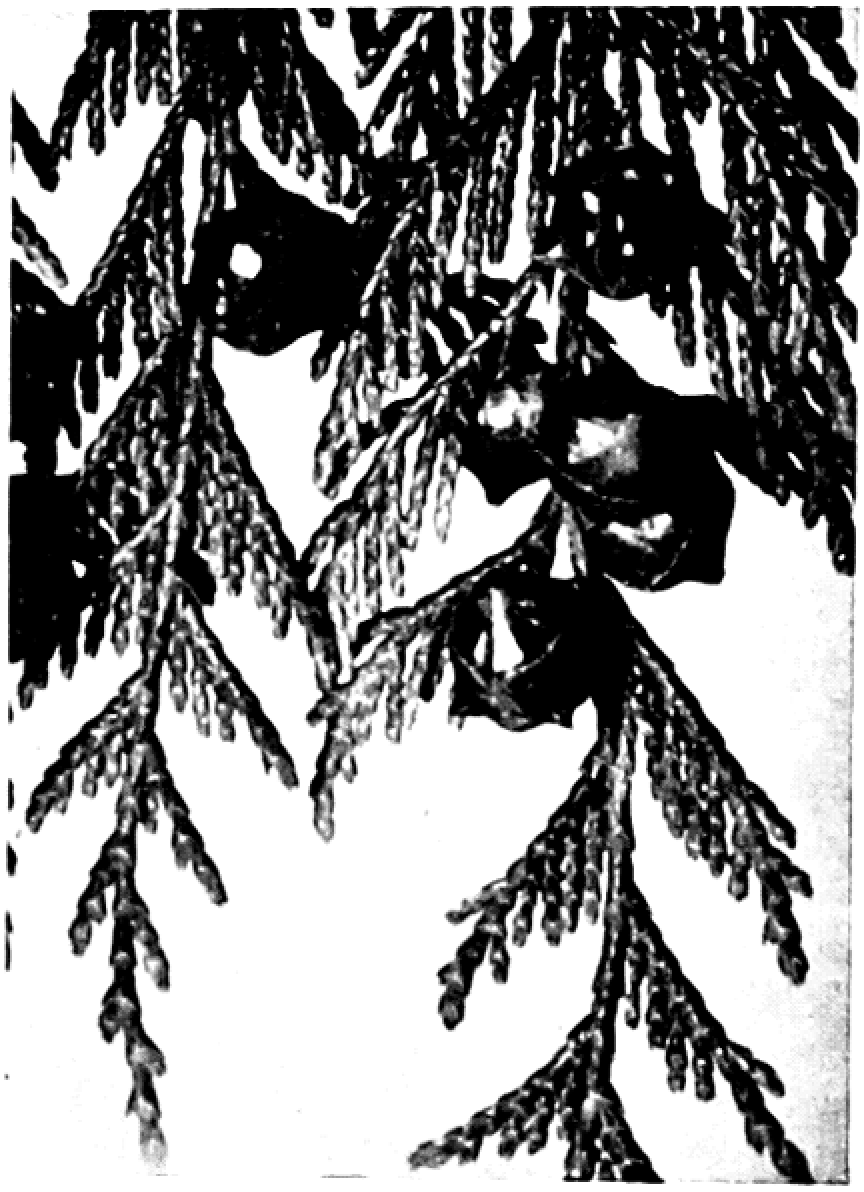
This brief review of our introduced forest trees gives some impression of their outstanding importance in modern forestry. Larches, spruces, and Douglas firs must be counted amongst our principal commercial trees, and their general success augurs well for future profitable timber production. As often as not, the British forester is required to grow trees which he has never seen in a wild state, and sometimes he has to deal with seedlings of species quite unfamiliar to him in their mature condition.

HYBRID TREES

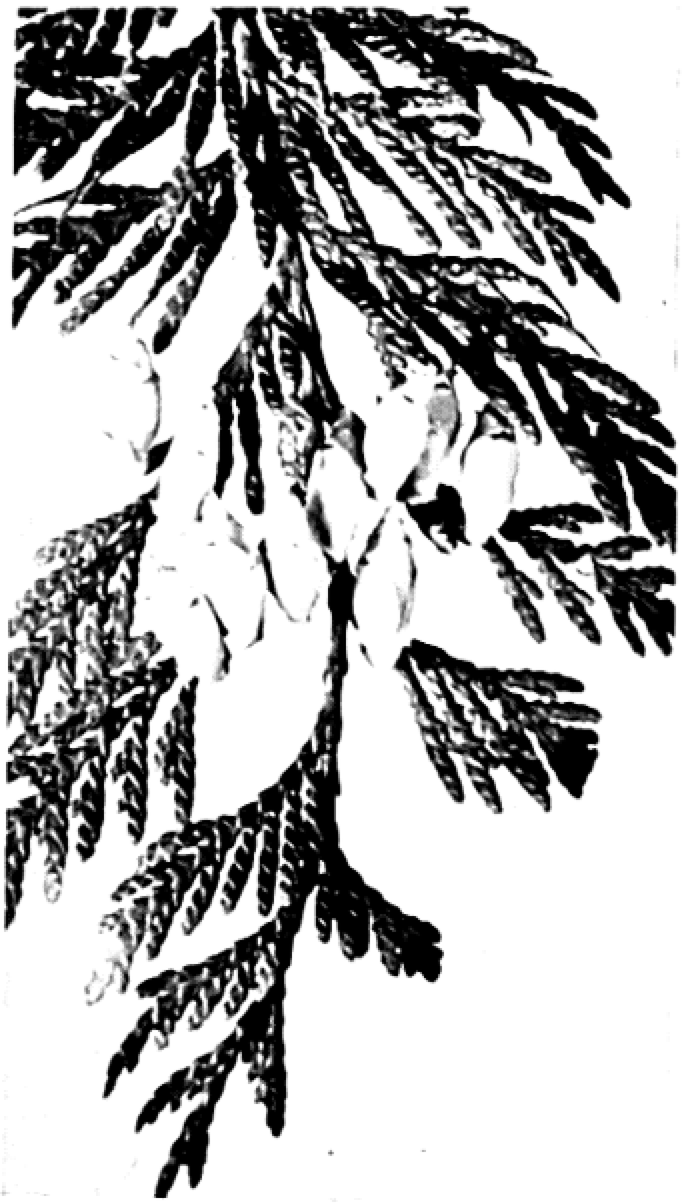
Although the full riches of the world's storehouse of timber trees have not yet been drawn upon, a further intriguing source of new timber producers has already been opened up. Hybrid trees arise from natural or intentional cross-breeding of closely allied species. Examples already used for forest planting are poplars and larches.

DUNKELD HYBRID LARCH (*Larix eurolepis* A. Henry) is a cross between European and Japanese larches which arose at Dunkeld, Perthshire, early in the present century. Its growth is more rapid than that of either parent, but as yet it is too scarce for general planting.

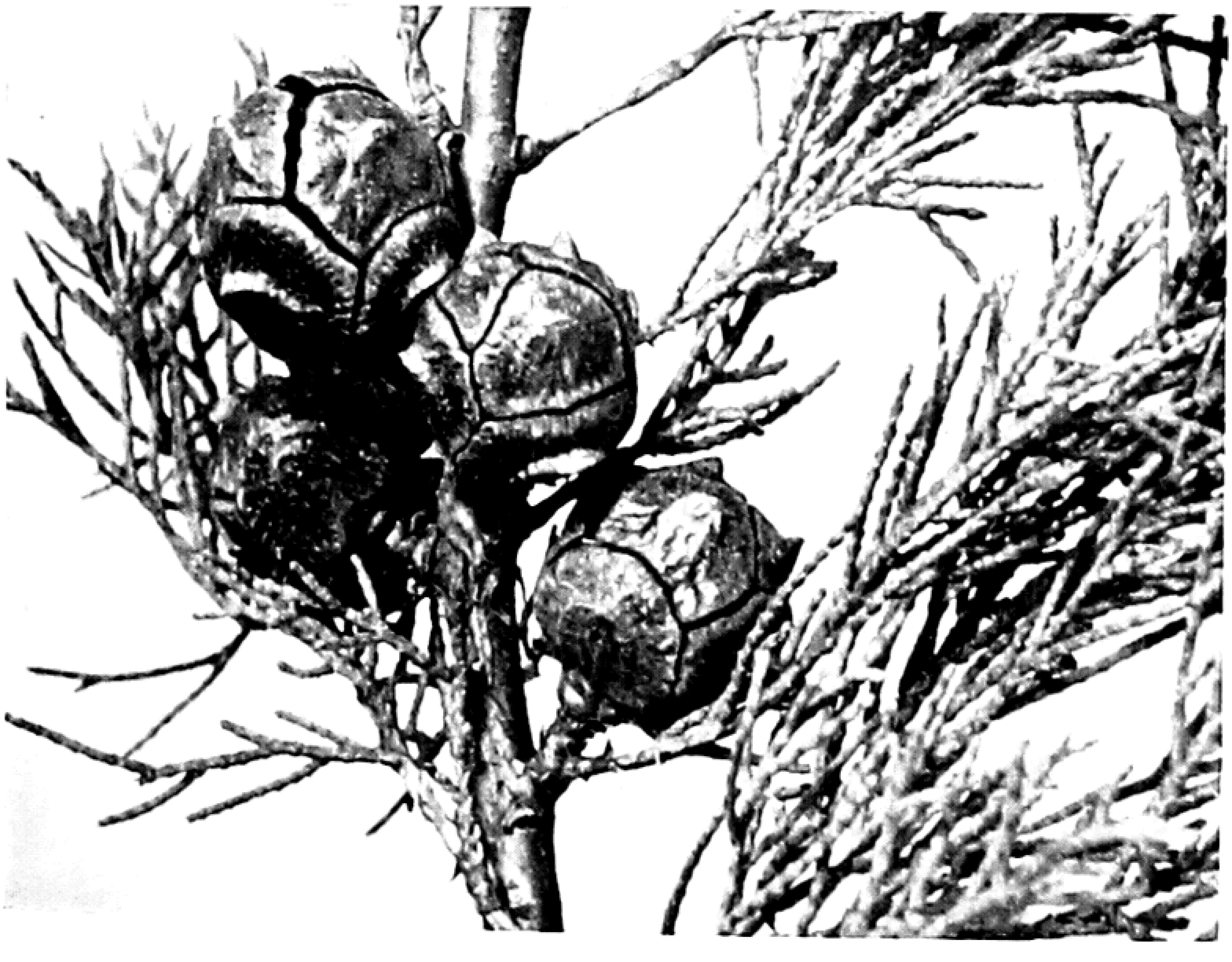
BLACK ITALIAN POPLAR, known as *Populus serotina* (Hartig) Moss, though more properly "*Populus nigra* L. var. *typica* Schneider × *Populus deltoidea* Marshall var. *monilifera* (Aiton) Henry," arose as a cross between European and American Black poplars about the year 1700. Only male trees are found. It is widely planted as a rapid timber producer on moist fertile soil, reaching heights of over 100 feet.



45 NOOTKA CYPRESS, *CHAMAECYPARIS NOOTKATENSIS*

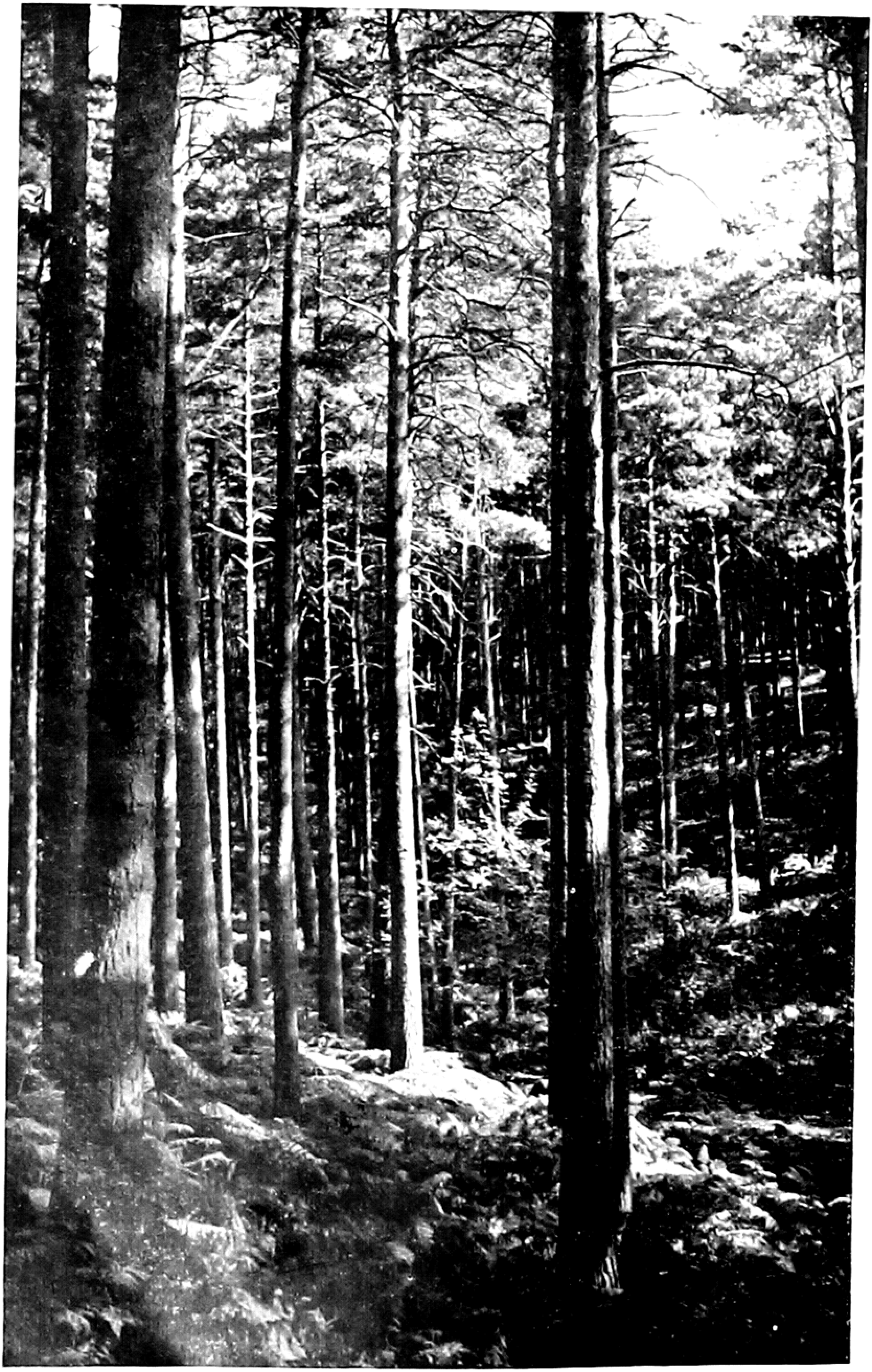


46 WESTERN RED CEDAR, *THUYA PLICATA*



47 MONTEREY CYPRESS, *CUPRESSUS MACROCARPA*

CONES AND FOLIAGE OF THE CYPRESS GROUP



48 SCOTS PINES ON THE GREENSAND OF WOBURN, BEDFORDSHIRE

CHAPTER 5

FOREST SOILS

Having considered the general trend of natural forest growth, and the life of the individual tree in its many varieties, one must turn next to the two most fundamental factors of the tree's environment, the soil which supports it and the climate in which it grows. These, working together, determine what kinds of trees will grow on each tract of land, their rate and form of growth, and the type of forest which they can form. Before bringing in new trees, or establishing new forests upon waste land, the careful forester will obtain a detailed knowledge of the local soils and range of climate with which he will have to deal.

THE BEDROCK OF BRITAIN

Soils arise through the breaking down of rocks under the influence of weather and of the vegetation forming the soil cover. These rocks are variable in chemical composition, structure, and mode of formation. Despite their small area, the British Isles contain nearly all the principle series of rock layers or *strata.* Broadly speaking, the oldest and hardest rocks lie to the north-west of Britain, the youngest and softest in the south-east.

Crystalline rocks of *volcanic* origin, such as granite and basalt, occur in Scotland, Wales and Ireland; also in the Lake District, Devon and Cornwall, but are rare throughout the rest of England. Although notable exceptions occur, most soils of volcanic origin in Britain are infertile, even for forest growth, and only support the less exacting coniferous trees.

Ancient *metamorphic* rocks, such as gneiss, arose through the transformation of volcanic or primæval sedimentary strata under conditions of great heat and pressure. They cover great areas of the Scottish Highlands, and also occur in the north-west and west of Ireland. The soils derived from them are notable for their infertile nature, but are usually able to support coniferous forests. The surface soils of both the volcanic and metamorphic rocks in Britain have usually been adversely affected by the compacting action of glaciers during the Ice ages; in places the glaciers have even swept the rocks bare of soil.

But the greater part of Britain is covered by *sedimentary* rocks laid down in successive beds or strata. These are derived from the breakdown of the primæval volcanic rocks which were formed in a molten state from the earth's original substance, and also in part from the metamorphic rocks which arose under stresses and strains as the earth cooled down. The action of wind and water, breaking down those original rocks, caused their constituents to be reformed on the beds of prehistoric seas in distinct layers which have since become reconsolidated.

The older and harder sedimentary rocks include the sandstones, limestones, gritstones, shales, and coal-bearing rocks which make up most of Ireland, Wales, Scotland south of the "Highland Line"; and most of England, except for the south-eastern areas dealt with below. Although there is naturally a wide variation in soils of such diverse composition, the general picture is one of reasonable fertility for tree growth (48).

Chalk is a sedimentary limestone of comparatively recent formation, and is only slightly consolidated; it is largely composed of the remains of minute marine organisms. A broad belt of chalk extends from Dorset north-west through the Chiltern hills to Norfolk, and reappears in the wolds of Lincolnshire and Yorkshire; offshoots of it form the North and South Downs of Kent, Surrey and Sussex, and the downs of the Isle of Wight. The Weald is composed of sands and clays which arose during the same geological period. Chalk frequently carries an extremely thin layer of fertile soil, and presents problems both to farmers and foresters. Fortunately its deeper soils, such as the clay-with-flints, may be induced to support beechwoods of the finest quality, whilst beech of useful size may be raised on the shallower soils of the steeper slopes with the help of coniferous nurses.

Younger even than the chalk, and still less consolidated, are the *Tertiary* beds of sands, clays, and gravels which cover a part of Dorset and Hampshire, much of the Thames basin, and a coastal strip of Essex, Suffolk, and Norfolk. Although their clays are frequently fertile, their sands and gravels are usually so poor that they remain uncultivated. Even for forest growth the Tertiary heathlands are remarkably infertile, and often only pines will grow on them.

The most recent rock-beds are quite unconsolidated into the form of hard stone. Indeed, in many cases they are still being laid down at the present day. These " *Recent* " strata vary from the rich *alluvial* and fen soils of the river valleys, which are excellent for alder, poplar, elm, and willow, to the sterile blown sands of the seashore on which forests of pines may be planted to check the inland drift of the sand dunes.

Finally there are man-made rocks, such as pit-head dumps, upon which trees are sometimes planted to hide the ugliness. Barren areas such as old gravel or chalk pits and iron-ore workings, often become clothed in scrub woodland even after man's industry has removed the fertile top soil.

The key to this complex pattern of British rocks and soils is the geological map. The one-inch-to-the-mile geological sheets published by the Ordnance Survey are particularly valuable. Indeed, the scientific study of British forestry is scarcely possible without their aid, for the soil and bedrock form the foundation of every plantation or stretch of natural woodland.

CHALK AND LIMESTONE

Most of the rocks mentioned above, although of varying age, hardness and texture, consist in the main of compounds of the element silicon. This may be associated with metals such as iron or aluminium, or occur as its common oxide, silica, but in either case it is chemically inert and plays only a very minor part in the composition and nutrition of trees that arise upon it.

But in chalk and limestone, the principal constituent is not a silicon compound, but a carbonate of calcium, or occasionally of an allied metal, magnesium. We have seen how these elements are essential to the tree, but the quantities needed are minute. When the general mass of a rock consists of calcium, the roots of any plant encounter special problems in their search for food. The lime rocks are alkaline in character, pervious to water, and in consequence very dry. But whatever water percolates through them dissolves small quantities of calcium compounds, so that the plants that grow upon them must avoid accumulating any excess.

So different are their soils to those found above other rocks, that special species of plants, termed *calciphilous*, grow upon them. Other plants, which cannot tolerate them at all, are termed *calciphobous*. Other plants again are indifferent. Most forest trees can grow upon lime soils in their youth, but towards maturity the effect of the calcium tells upon some, and many decline, particularly where the surface soils are shallow.

Typical lime-loving trees are ash, beech, and whitebeam. Oak, birch, and Austrian pine tolerate a lime-rich soil. The growth of other trees, such as Sweet chestnut, Scots pine, and Norway spruce, is usually poor upon chalk or limestone. Yew is equally at home on either type of soil. The type of forest naturally differs, as does the nature of the ground vegetation, on lime and non-lime soils (49).

FOREST SOILS AND FERTILITY

In contrast to farm crops, forest trees thrive on relatively infertile soils. Certain species, such as oak and elm, only develop good timber on the richer soils, but most coniferous trees will grow upon ground too poor for profitable cultivation by the farmer, and yet produce good timber crops. There are three main reasons for this.

Firstly, the tree's roots extend indefinitely, and keep on growing year after year, taping wider and deeper layers of the soil and subsoil.

Secondly, trees in the forest grow in ruthless competition with their fellows, and as the years go by, some fall behind and succumb from lack of light. The competition of their roots is consequently eliminated, and the surviving trees can penetrate into new ground.

Thirdly, and most important, the forest *feeds itself* with *humus*, the decaying organic matter of its own fallen leaves and stems. The richest humus is formed from the soft leaves of the broadleaved trees, which fall every autumn to form a rich carpet of leaf mould upon the forest floor. The needles of the conifers persist for two or more seasons, but they too finally fall in autumn and slowly decompose. Trunks and branchwood, unless removed, also decay at length and return their store of mineral salts to the soil; the same occurs when they are burnt to clear the ground for the next crop. It follows that soil which has carried a forest crop may be richer than it was before, even though a portion of its produce has been removed as timber. Old woodland soil is especially valuable for planting new tree crops.

Fertility depends on many factors, such as the physical texture of the soil, its chemical composition, the depth down to the parent rock, drainage, and previous cropping and cultivation. Important are the amounts available, in forms which the trees can use, of the essential mineral elements, potash, phosphorus, and nitrogen. The nature of farm crops—or their absence, in the vicinity of the forest—gives a useful clue to the fertility of each locality; but it must be remembered that the poorest land has often been left under trees, simply because it is too poor for the farm crops that flourish in the fields adjoining.

Mention must also be made of the interworking of physical, chemical, and biological factors which causes the fertility of any soil. Soil is something more than finely divided earth. It is at once the scene of constant chemical activity and the home of minute organisms such as *protozoa*, *bacteria*, and *fungi*, as well as animals such as earthworms and some forms of insect life. In the case of agricultural soils these have been closely investigated, but little is known of their nature in the rather different soil structure of the forest.

SOIL WATER, AIR, AND DRAINAGE

The rainfall throughout Britain is everywhere adequate for tree growth, and it is never necessary to irrigate tree crops. Excess of water in the soil is frequent, and may restrict tree growth because it excludes air. Without air, tree roots cannot breathe, and therefore they never develop in stagnant water or waterlogged soil. Certain common trees, such as alder, poplar, and willow, are adapted to growth in marshy ground, but only where the moisture is *moving*, and not stagnant; e.g. where seasonal variations occur in the water level within the soil.

Waterlogged soils can be made fit for afforestation by drainage. Open drains are the rule, as tree roots choke pipe or tile drains and render them ineffective. Draining is sometimes combined with " turf-planting," in which the trees are set in or through the upturned turves extracted when making the drains. Another effective form of drainage is partial ploughing. The open furrows, if properly sited down the slopes, form excellent subsidiary drains which can be keyed in to a system of larger main drains in the valley bottoms. Ploughing is much cheaper than draining by hand, and it is probable that in the future draining machines will speed the work on large areas with suitable soils.

ROOTHOLD

In forests, the soil must perform a function which is of comparatively less importance to farm crops—that of anchorage. Shallow soils, wet soils, and many clays, give a poor roothold; gravels, and deep soils overlying weathered rock, a good one. Not even the stoutest of trees can resist the winter gales if its roothold is insecure (8, 9, 50, 51).

SOIL PANS

Many farmers are familiar with soil " pans," hard layers of soil that lie about a foot below the surface and prevent the roots of plants from penetrating any further. These arise sometimes by chemical action, sometimes by the continued use of implements set to the same depth, as with " plough pans." Such pans have a threefold adverse effect upon tree growth, for they limit the depth of the great roots upon which the tree relies for its mineral food, they interfere with drainage and keep the surface layers too damp, and they prevent the development of effective roothold.

Great expanses of heathland remain so far untouched by the farmer and forester alike because of " moor-pans" and " iron-pans." The presence of these may often be detected by examining cuttings in the ground or by digging soil pits. The pans show up as hard black or reddish layers, usually forming a contrasting division between the light-coloured surface soils and the darker bedrock beneath. The surface soil layers are often white or pale grey because much of the minerals, including those useful as plant food, has been washed down into the pan below. Fortunately such soils can frequently be made suitable for forestry by deep ploughing with tractor-drawn ploughs to break up the pan.

CULTIVATION AND MANURING

Forest trees, like lesser plants, thrive best upon land that has undergone cultivation, and for much the same reasons. Drainage, aeration, fertility, and roothold are improved, and pans, if present, may be broken up. The ploughing of land before planting has been developed, firstly in Germany with steam tackle, but latterly in Britain with steel-wheeled or track-laying "crawler" tractors. It is usual to " half-plough " the ground, leaving alternate furrows untouched, as this proves best for drainage. Indirect advantages are the suppression of weeds and the lessening of fire danger. Obviously, only new ground can be treated in this way (132). Old woodland is full of tree stumps which prevent the passage of the plough.

The manuring of forest crops has made very little progress, largely for economic reasons. Manures, whether organic or of chemical origin, should theoretically do most good in the early stages of the tree's growth; later on the leaf mould from the trees themselves should continue the good work. But as the trees will not be felled for many years after the manuring, the long wait for the uncertain return on the capital costs involved has deterred woodland owners from using fertilisers, except in their forest nurseries. There the methods most usually adopted involve dressing with farmyard manure, leaf-mould, or vegetable composts, or else green manuring.

TREELESS SOILS

Although trees, of one kind or another, will succeed on most sorts of soil, there remain areas that do not naturally bear forest and are unlikely ever to be afforested by man. Swamps may be drained and heaths ploughed, but some other areas are unsuited to trees for chemical or physical reasons. Such are the screes or loose rock masses of the hills, besides steep rock surfaces and out-crops of naked bedrock, salt marshes and the like.

There, though climate be favourable, the forest cannot grow. The converse occurs on high mountains, where, though the soil be fertile, the climate restricts the growth of trees. These two factors work together, sometimes favouring, sometimes restricting, the spread of trees over the surface of the land. Wherever trees gain a foothold, they tend to enrich the soil and build it up. Their roots assist the weathering of the rocks, whilst their leaves add humus to the surface layers of the soil. The forest acts, therefore, as a geological agent, tending to build up soils suited to its own growth.

CHAPTER 6

TREES AND THE WEATHER

Trees, whether planted by man or arising naturally in the wildwood, are adapted to life under a wide range of weather conditions. Rain, sun, and wind are alike essential to their growth. Only the extremes of weather may prove harmful. Seedlings and young growing shoots are susceptible to weather damage, but the main bulk of the grown tree is resistant in the extreme.

The tree's most striking method of escaping damage from cold in temperate climates is its habit of winter rest. In the moist tropics most trees are evergreen and grow throughout the year; but in Britain the winter resting period sets in about October and persists until April. Most broadleaved trees, and a few conifers, shed their leaves; whilst all trees, deciduous and evergreen alike, bring their life processes almost to a standstill. Shoot growth ceases, and a winter bud forms at the apex of each shoot, in readiness for next year's activity.

In this dormant state the tree can endure great cold. The water content of its cells is low in proportion to the solids which they contain, so that damage by the freezing of its tissues is rare. The deciduous trees also escape wind damage, for they carry no leaves at the season of the severest gales. But for five or six months of every year a tree, in our climate, makes no effective growth. Not only are the temperatures too low, but the hours of daylight are so short and the sun's rays so weak, that comparatively little light energy is available for its important nutritive process of photosynthesis.

The various factors of light, heat, wind, and rainfall, which together make up the weather, will be considered in detail. Each, in moderate degree, is essential for the tree's life; but any of them, in excess, may prove harmful or even fatal.

LIGHT AND SHADE

Though light is essential for the life of trees, as of all green plants, the different species vary greatly in the intensity of light which they require. Many, such as oak, ash, pines, and larches, can only thrive in the clear and uninterrupted light of the open sky. These are known as *light demanders.* Others, such as beech, spruces, hornbeam, and hemlock, will grow beneath the shade of other trees, and are therefore called *shade bearers.*

Each tree, of whatever species, makes its own arrangement of branch and leaf to utilise the available light to the full. Thus, the leaves of the beech are pale green, small, and hard-textured in the sun, but darker, broader, and softer when growing in the shade. They grow in beautiful mosaic patterns so as to intercept all the useful light that comes their way. In certain Silver firs the needles are short, erect, and crowded in the sun, but grow longer, more loosely, and more sparsely on the shaded branches.

Trees do not suffer from too intense sunlight in Britain, and the modifications in structure that they make to meet that danger are too small to be seen by the naked eye. They consist principally of deeper cells in the surface

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layers of the leaves. There is ample light during the summer growing season for trees to grow even in the most northerly parts of Britain, though the shade-bearers tend to need more light in the shorter growing season of the north.

HEAT, DROUGHT, AND COLD

The warmth of the sun is as essential for trees as is its light. All their vital processes are carried on in a liquid medium, and can only proceed when the temperature is above freezing point. Thus, they cannot extract water from frozen soil, and the sun must warm the soil as well as the air before their growth can begin in the spring.

In excess, heat is usually allied with drought, and causes damage by compelling the tree to transpire water more rapidly than it can be replaced, so that delicate cells are desiccated and killed. Trees usually strike down deeply with their main roots to the vast stores of underground earth moisture, so that the longest drought leaves an established tree unharmed.

Only under cultivation are our trees seen to suffer greatly from too intense heat and drought, and then only in the youngest stages. Seedlings of such shade-bearing species as the spruces cannot endure prolonged spells of hot dry weather. Unless they are protected by artificial shade, they wilt and die; for in a state of nature they normally grow in the shade of other forest trees. Drought is also a major cause of losses amongst newly-planted trees, especially if it occurs in late spring when the leaves commence to grow before the roots are firmly in contact with the moisture of the soil.

Frost in winter rarely harms the grown tree, although cracks in the trunk are sometimes attributable to intense cold freezing the contents of certain wood cells (*frost-crack*). But in the seedbeds tiny seedlings may be raised from the ground by the freezing of the surface layers of the soil (*frost-lift*). The thaw leaves them high and dry, and they seldom recover. The forester sometimes guards against this by covering the seedbeds with leaf mould, which seldom freezes and does not expand much when frozen, so does not tend to lift the seedlings from the ground. The screens used as a protection against the sun, may also be used to shield young seedlings from sharp frosts.

Hard frosts prevent the planting of trees, and at such times any that have been lifted must have their roots protected from the cold. If the ground is soft enough, a shallow trench may be dug, and the plants " heeled-in " by inserting their roots in it. Or they may be stacked in a round heap, with their roots to the centre and their shoots pointing outwards, and the whole pile covered with straw.

LATE FROSTS AND FROST HOLLOWS

It is the late spring frosts that are the source of the greatest damage to the forest, as they are to garden and orchard. When the tender young shoots, leaves, and flower-buds are expanding rapidly in April and May, a sudden frost may kill them right back to their base, so that a season's growth is lost. Oak, beech, spruce, and larches all suffer severely (*frost-tender*), but other trees, such as birch, hornbeam, and the pines, are more or less immune from frost damage (*frost-hardy*). A large degree of protection is given to delicate species by hardier trees growing near them, and these are therefore sometimes planted in mixture as temporary " nurses."

Late frosts are especially severe in *frost hollows*. These are relatively low-lying pockets of ground, such as valley bottoms, in which cold air accumulates on still, clear nights. Their presence is frequently shown by belts of mist in the evenings, and their location and character are usually well known to the countrymen of the neighbourhood. If frost-tender trees such as beech are planted in these hollows, they have but little chance of ever growing up through the frosted levels to the warmer zones above, for every spring their leading shoots will be cut right back to their starting point.

TREES AND THE WIND

The movement of air that is the wind is usually helpful to tree growth. It ensures a never-failing supply of the carbon-dioxide gas from which the tree's tissues are so largely built up, as well as the oxygen gas which the tree breathes. Also, it brings the rain-clouds.

The tree cannot escape the wind, and as it grows taller it becomes steadily more exposed to its force. So its structure, and especially its trunk, are so designed that they may resist this force. The fibres of wood and branch are strengthened and disposed to meet the constant strain. A nice balance is maintained between the pull of the wind and the opposing thrusts and strains of the trunk, a balance that leaves the tree with a margin of safety in all but the most violent of gales (2).

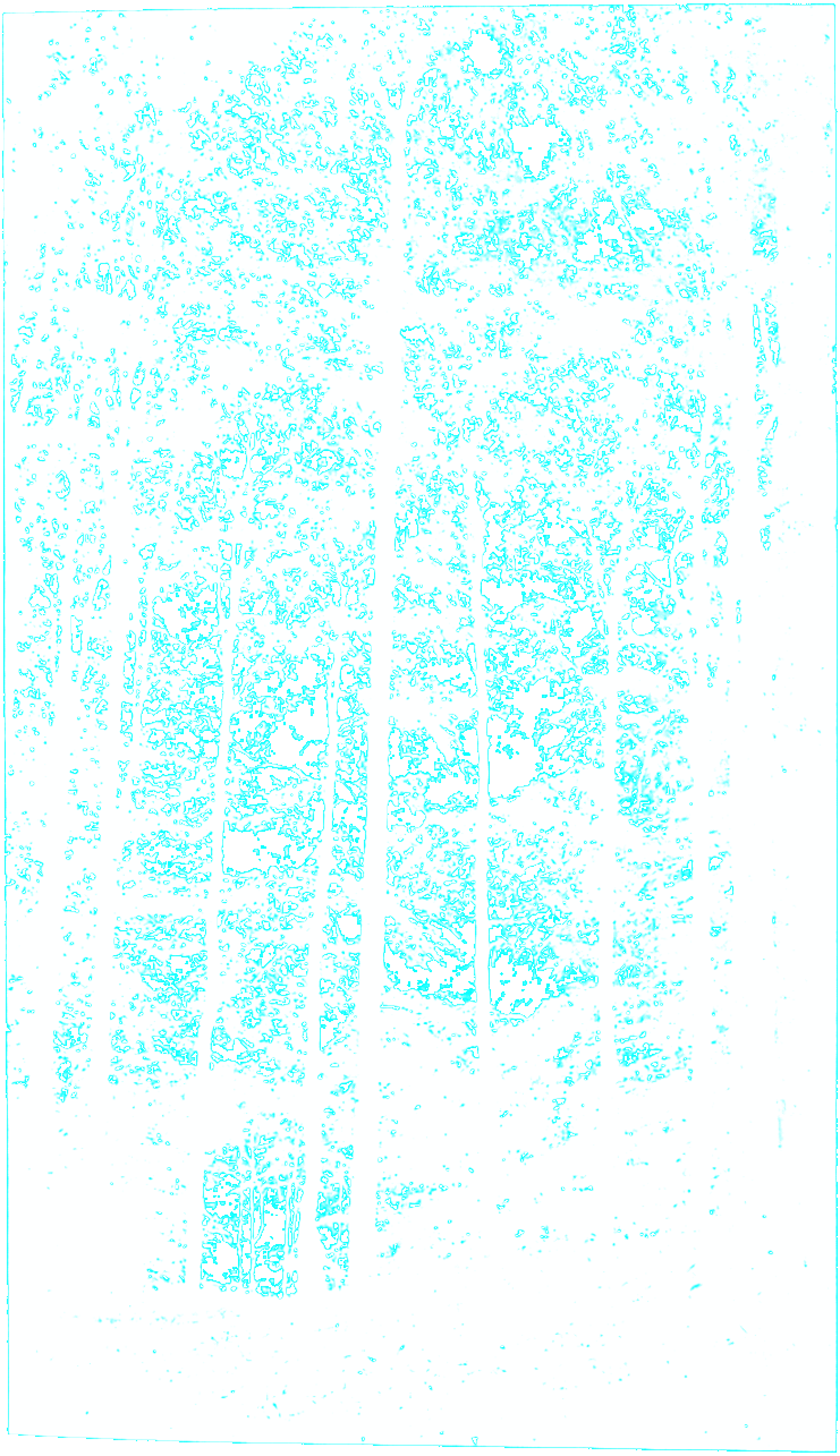
At times, however, this balance is upset, sometimes through natural causes, more often by man's action or neglect. Then *windbreak* or *windthrow* results, a fatal disaster for the tree. The tree may fall in one of two ways. Its roothold may give, or its stem may snap. Only a tornado will break the trunk of a healthy tree that has grown in full exposure to normal gales, but if decay is setting in at its heart the stoutest tree must give way, sooner or later, to the fury of the winter winds. Uprooting most often occurs when the ground is sodden through heavy rains preceding a gale, or where drainage has been neglected (50, 51).

Soils differ in the degree of roothold which they afford to trees. Windthrow is commoner on some soils, such as clays, than it is on gravels and soils overlying rocky strata, whilst shallow soils give poor roothold.

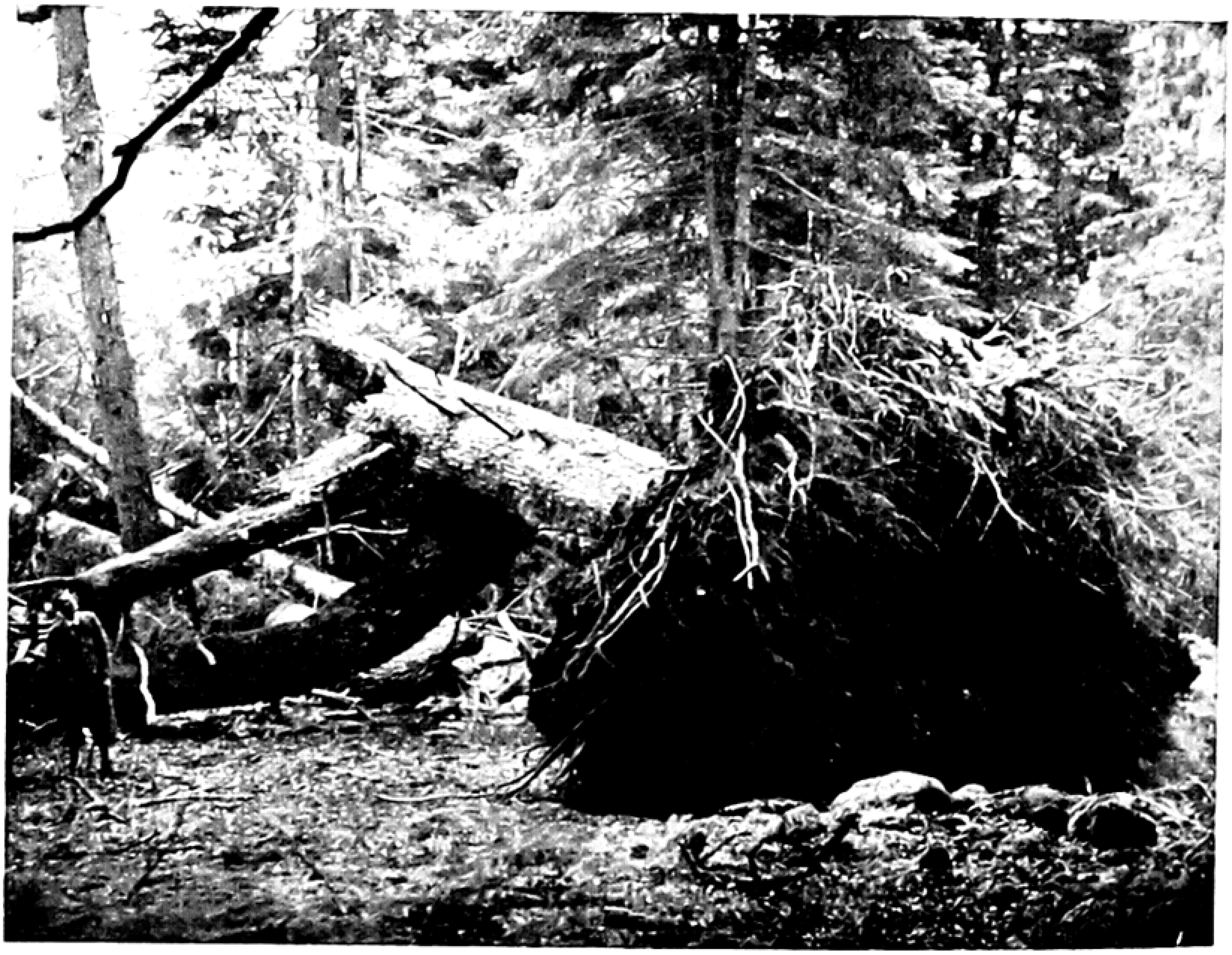
With trees grown close together, windthrow is more common, especially so in young coniferous plantations. But it usually arises from a defect in their management. Trees left for years to grow too close together, force one another up without acquiring individual wind resistance, either of stems or roots. When at length a thinning is made, or the wood is exposed by the felling of taller trees close by, the young trees fall like ninepins before the first gale. Spruces, larches, and Douglas fir are those which most frequently suffer, because in their case the correct degree of thinning is difficult to judge; but all three become wind-firm when open-grown. The way to avoid such windthrows is by frequent, early, and careful thinnings.

PREVAILING WINDS AND WINDBREAKS

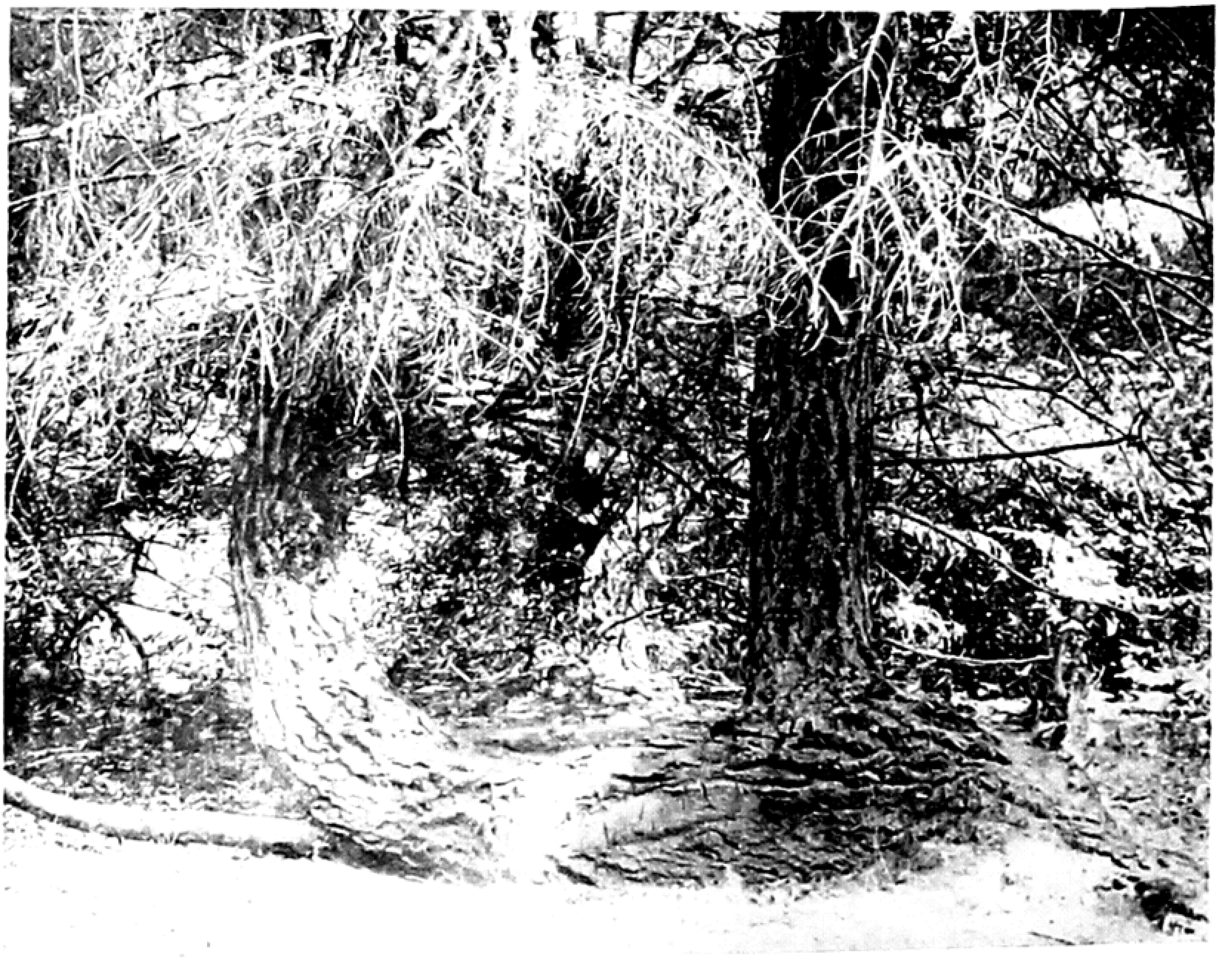
Throughout Britain the prevailing winds blow from the south-west, but at certain seasons north-easterly winds are frequent. Along the coastline, and on exposed ridges further inland, these winds mould the form of outlying trees, causing the crowns to grow away towards their lee. Thus, such trees, whether grown in isolation or in narrow belts, assume a typically lop-sided outline.



49 TALL BEECHES ON THE COTSWOLD LIMESTONE AT KINGSCOTE, GLOUCESTERSHIRE



50 WINDTHROW AND WINDBREAK: A FALLEN SILVER FIR NEAR INVERARAY, ARGYLL



51 RECOVERY: TWO SIDE BRANCHES OF THIS WINDBLOWN DOUGLAS FIR HAVE DEVELOPED INTO TIMBER TREES

This effect is due not only to the force of the wind, but also to the salt which it carries. During the spring growing season, when gales are frequent, this salt scorches tender shoots and leaves wherever it falls, generally on the seaward side of the trees or woods. Trees differ in their susceptibility to the moulding power of sea winds. Oaks are bent to an extreme degree, but Austrian pine stands erect on the wildest of coastlines. Larches fail where salt winds are frequent.

The forester guards against this damage by planting *windbreaks* of hardy trees such as pines on the windward side of plantations. Similar windbreaks are planted to shield gardens, farmsteads, and agricultural land. Away from the sea, beech and sycamore are suitable windbreak trees, but in their early stages they are best nursed up by an intermixture of Scots pine. The shelter of trees is appreciated by man and beast alike in wintry weather. Stock thrive better when they do not continually lose their body heat to the chilling winds. Cattle in particular are naturally woodland beasts, and the shade of trees in summer, and their shelter from the winter's cold, are helpful even to the hardiest of stock (55).

Besides salt, the wind transports other solid and gaseous matter which may prove harmful to tree growth. In particular, the smoke and sulphurous fumes from the great industrial areas check the growth of coniferous trees planted to leeward.

WIND-BORNE SEEDS AND POLLEN

In certain respects the wind is an essential agent in the life of many trees, including most of our important timber producers. It carries the pollen from the male flowers to the female ones, so enabling fertile seed to be set; and it also serves to distribute winged seeds. The tiny seeds of the birches may be wafted for miles by a high wind, enabling those trees to spread rapidly over large areas; but the seeds of ash, sycamore, and many conifers are large in proportion to their wings, and so can only travel a matter of a few score yards.

The forester can make use of the wind in certain methods of *naturally regenerating* woodlands. If he fells a strip of trees, leaving well-grown seed-bearers to windward, these *mother trees* will scatter their windborne seeds over the whole area; and if conditions are right, a new crop will arise without the work of planting (124, 125).

FORESTS AND RAINFALL

Water is essential to the growth of trees, and throughout the world forests are only found in regions of adequate rainfall. The driest districts of Britain, towards the east, receive only twenty to twenty-five inches of rain a year, of which only half falls in the growing season. Most species of trees find this amount adequate, Scots and Corsican pines thriving exceedingly well in the low rainfall areas. Towards the west, much heavier rain, often over one hundred inches per annum, falls in the mountainous districts, the greater part of the fall being in winter. Under such conditions the spruces thrive.

Rain, even in excess, is seldom harmful to the grown tree. In the nursery, summer storms play havoc with seedbeds, but the damage is mainly caused by the surface run-off of rainwater. This may be prevented by raising the actual seedbeds above the level of the surrounding ground.

Forests are often supposed to increase the rainfall of an area, but this has never been conclusively proved. The writer has seen a windbreak of beech high on the crest of an exposed down, dripping with the moisture condensed from a cold damp mist sweeping over the hill; in the open, no rain was falling. Anyone who walks through the woods on a still winter's day, when the mist hangs thick about the trees and the warmth of the sun is slowly melting the previous night's hoar frost, will hear the constant drip, drip, drip, of the water which the trees have garnered from the damp air.

These are simple practical examples of the meteorological theories which argue, on various complex grounds, for an increased "precipitation" of water, in the form of rain, snow, frost, hail, or dew, over wooded country as compared with open plains. But this is a difficult factor to measure and compare, and final and convincing proof is lacking.

What is certain, however, beyond all peradventure of doubt, is that forests increase the amount of rain *absorbed by the soil.* Of all the rain that falls on the land surface of the earth, a portion is evaporated into the air, another portion is transpired by green plants, a third part absorbed into the soil to reappear as springs, whilst the remainder runs off the surface into streams and so towards the sea. This *run-off* water is of no use to agriculture. It erodes the soil, causes sudden floods, and washes down silt to choke rivers and reservoirs. Its proportion varies greatly, being highest on bare land, less on ploughed ground, grassland, land under crops, and the least of all in the forests.

The water that sinks into the forest soil emerges later in a controlled flow to feed the streams from springs. Forests are therefore a most desirable soil covering in water-catchment areas (158), on hill sides where erosion is damaging the soil, and in river valleys where silt is clogging the stream beds, or where the "water table" is falling below the level needed for good agriculture.

SNOW, HAIL, AND ICE

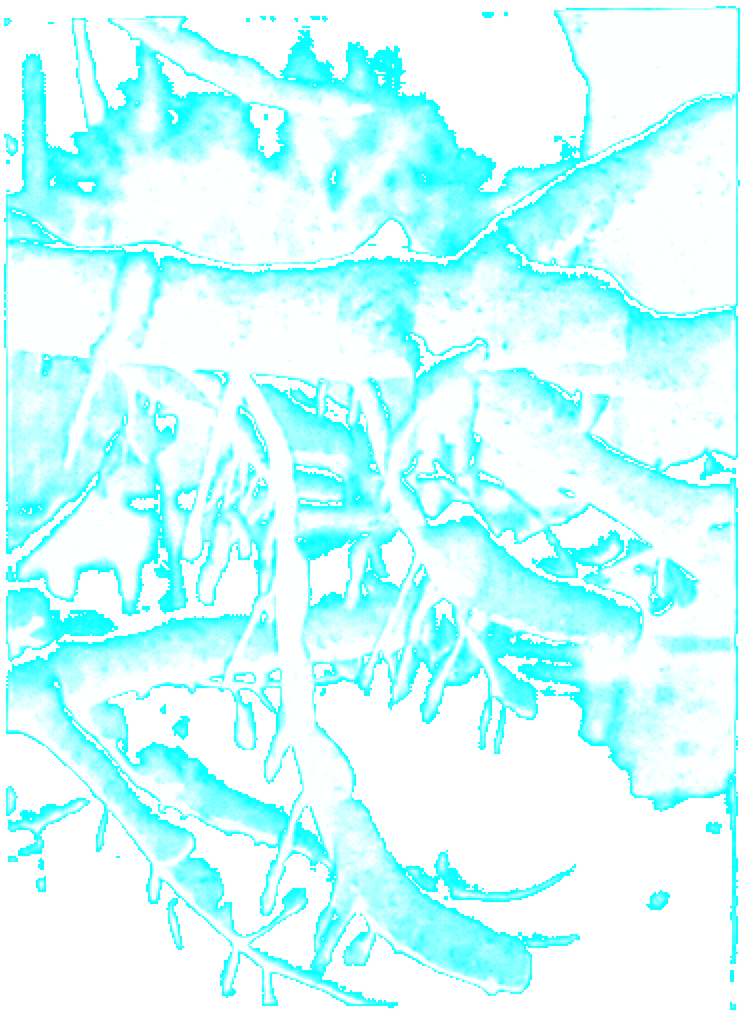
Deep snow is infrequent over most of Britain, and as it comes in the dormant season of the year, the forests seldom suffer (52, 53). Minute seedlings are able to survive burial beneath a snow carpet for months on end, and though snow calls a halt to all planting operations, newly-planted trees seldom seem to suffer any harm. *Snow-break* of branches may occur in the young plantations of coniferous trees, but it is not a major danger. Certain imported trees, such as hemlock, Lawson cypress, and thuya have drooping leading shoots which throw off the snow so that it cannot damage them.

Hail rarely does severe damage to our woodland trees, though it may bruise shoots or tear through delicate leaves. But ice, in the rare form of *ice-storms*, or "glazed frost" can prove very harmful. This ice, or rime, is a form of hoar frost that forms in great thickness on all exposed surfaces under exceptional climatic conditions (54). The extra weight causes stout branches to break, and even whole trees to fall asunder.

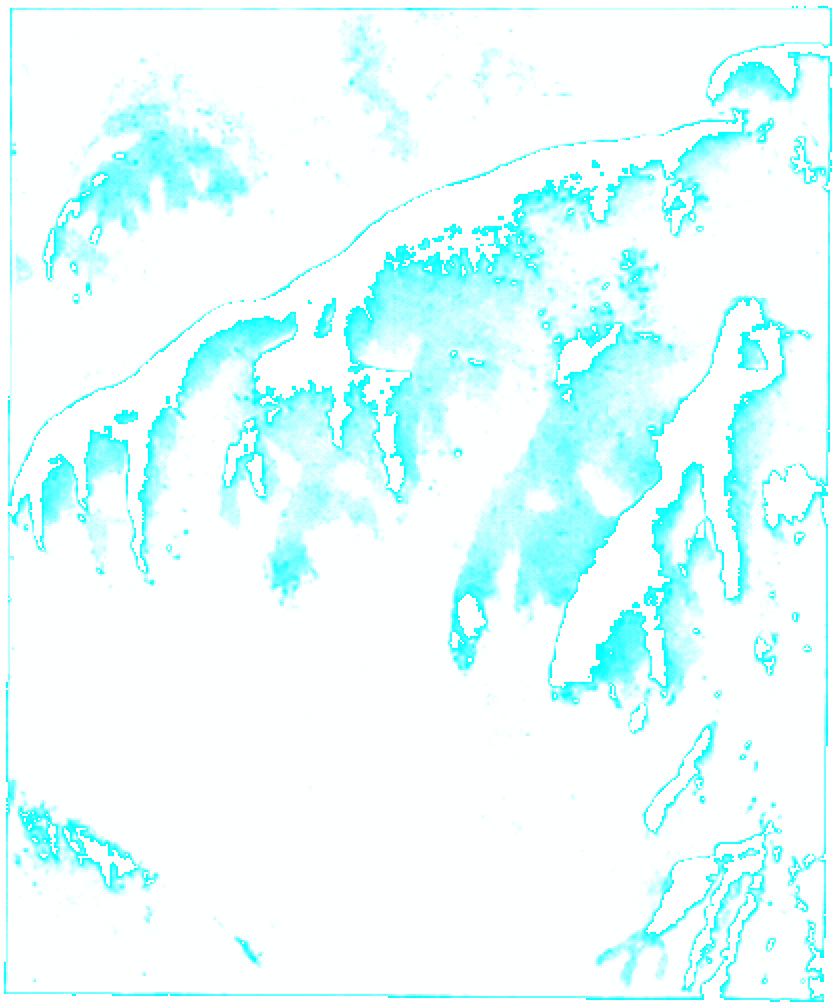
LIGHTNING AND FIRE

Lightning is a rare calamity, but may be fatal to the tree which it strikes. The passage of the electric charge develops enormous heat within the trunk, converting its water content to steam, which shatters the trunk with explosive force. The writer has seen a stalwart larch riven before his eyes in this way. Sometimes the broken trunk smoulders, and in dry weather the wind may fan the blaze until a forest fire is started. Fires of such origin are rare in Britain, and only occur in coniferous woods.

It is never safe to stand beneath any tree in a thunderstorm, for the simple

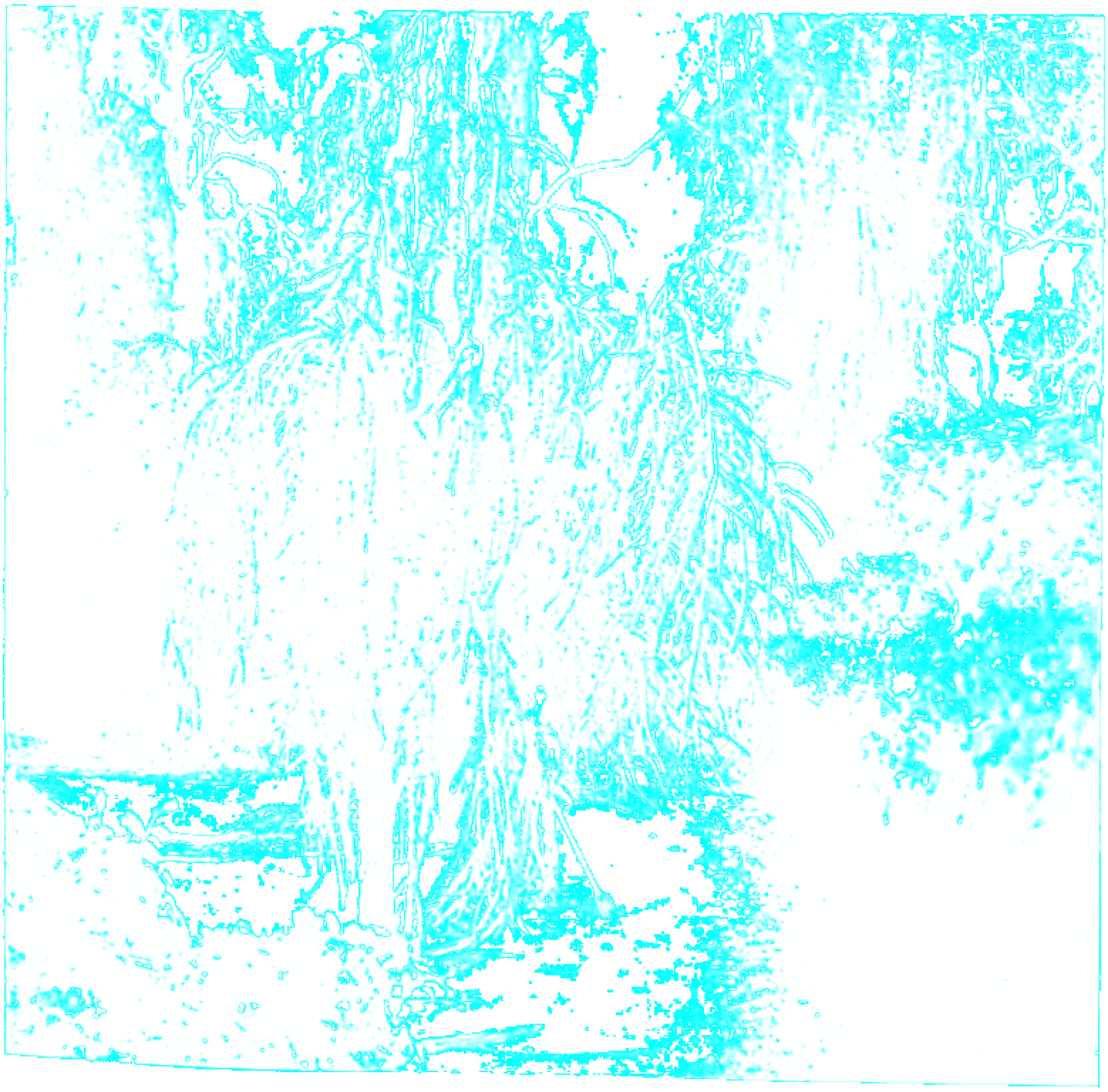


52 BARE TWIGS OF ASH

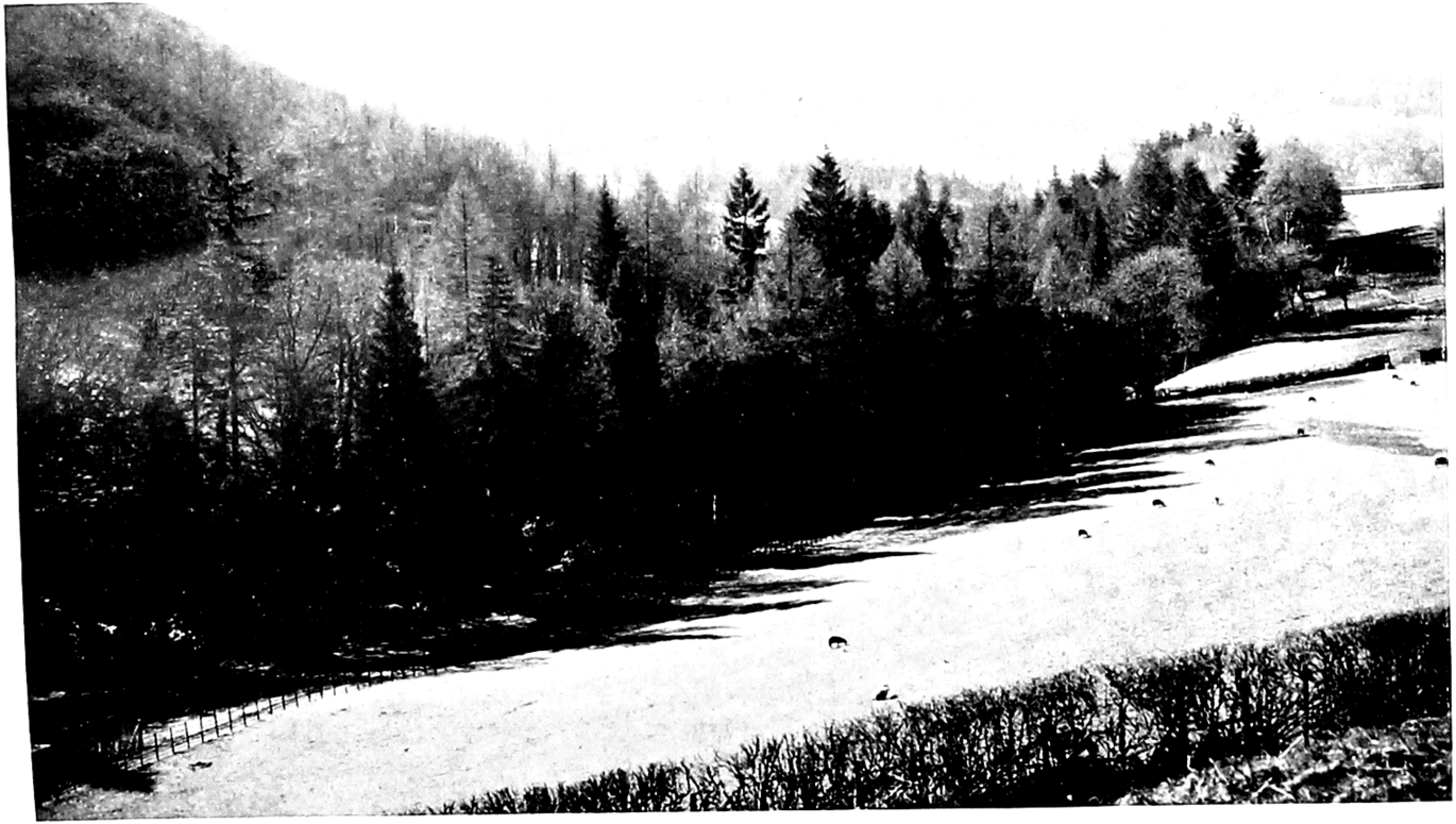


53 EVERGREEN SPRUCE SPRAYS

SUPPORT UNHARMED A GLISTERING CANOPY OF WINTER SNOW



54 THE GLAZED FROST OF AN "ICE-STORM" OUTLINES THE TRACERY OF WINTER TWIGS



55 A SHELTERBELT OF CONIFERS PROTECTING THE FARM LANDS OF VIVOD, DENBIGHSHIRE

reason that the lightning may find an easier passage to the ground through the human body than through the lowest portion of the tree trunk. But unless the tree be isolated, the risk in the forest is little greater than in the open.

Rough-barked trees, such as oaks, suffer most from lightning. When it strikes smooth-barked trees, such as beech, it may find an easy downward route through rain-water coursing down the bark, and so reach the ground without harm to the tree.

ELEVATION, EXPOSURE, AND ASPECT; THE TREE LINE

The local weather at any place varies with elevation above sea level, exposure to the prevailing winds, and in hilly country, with the aspect, meaning the direction of the principal slope. The high mountains of Britain rise above 4,000 feet; but the area over 2,000 feet is small, and most of the land surface lies between sea level and 1,000 feet. The mountainous areas lie mainly towards the west, and are remarkable for their high winter rainfall. They are also cooler than the plains, not only on account of their height, but also because of their frequent cloudiness.

Extreme exposure has an adverse effect on tree growth, and the shelter of hills proves more favourable for forests. As the strongest winds blow from the south-west, it follows that an easterly aspect often produces better timber than does a westerly one.

The idea of the *tree-line* or *timber-line* is useful in considering tree growth at high altitudes. We have seen that there are mountains too high, and lands too northerly, for any trees to grow. Trees do not cease at any fixed elevation or line of latitude, for local conditions vary greatly; but they gradually become more and more stunted under the influence of cold and exposure, until at length they disappear entirely.

In the far north the tree-line descends to sea level, but in the Alps, Himalayas, and Equatorial mountains, trees grow at heights of many thousands of feet. The height of the tree-line in Britain has not yet been ascertained with accuracy, but except near the west coast it is probably everywhere higher than one thousand feet, yet seldom rising above the two-thousand-foot mark. Much depends on the presence of still higher land, which may act as shelter, in the near vicinity. By far the greater part of Britain is therefore available for tree growth, but within the present geological epoch the highest peaks have never carried forest, nor are they likely to do so.

PIONEER TREES

In the foregoing paragraphs certain trees, such as birch and certain pines, have been mentioned as resisting all the elements alike. They need full light, but defy frost, drought, and gales, and are therefore well suited to growth on open ground. They are the *pioneer* trees of the advancing forest.

Others, such as beech and spruces, stand in need of shelter. They suffer from spring frosts, and dislike high winds in their younger stages. On the other hand, they endure shade and are thus enabled to thrive in the shelter of other trees, and to succeed them in course of time. Such trees are known as *successors.*

THE CLIMATE OF BRITAIN

The climate of the British Isles is influenced in a marked degree by the Gulf Stream, a warm sea current from the south-west. This combines with the prevailing south-westerly winds to produce a " Westerly Maritime " climate, very different from the " Continental " climate of Central Europe. The difference is most marked in winter, when the temperatures in Britain are some 30 Fahrenheit degrees warmer than the latitude would suggest. The British forester is therefore able to transplant his trees throughout the winter months, whilst his continental neighbour has his woodlands deeply clothed in snow.

Another curious result is that whilst in summer, as one might expect, the south of Britain is warmer than the north, in the winter the direction of temperature difference is altered, and the *west* is warmer than the *east.*

Temperatures throughout the country are modified by the nearness of the sea. In coastal districts the mean maximum and minimum temperatures in summer and winter vary by only 20 Fahrenheit degrees, from 63 degrees in July down to 43 degrees in January. In inland districts, such as the eastern Midlands, the variation is much greater, by 40 degrees from 71 degrees right down to 31. Trees in inland areas therefore have to face a much wider *range* of climatic conditions than do those on the coast.

Elevation introduces yet another factor, for everywhere the mountains are cooler than the plains, and have a higher rainfall.

The interaction of all these factors results in a wide variety of *local climates.* Consequently a system of forestry suited to one district may fail in another, for climatic as well as soil reasons. Districts with similar climates may have diverse soils, whilst areas with the same rock beds may lie in widely differing climatic zones.

One curious feature of the British climate, common to most districts, is the unwelcome spring drought of April and May. This not only causes planting losses, but also increases fire risk, as it coincides with a time of year when the surface vegetation of grass and bracken is dead and dry.

Another feature which affects tree growth is the absence of a sharp dividing line between winter and summer. The British spring is early but fickle. Trees from inland or eastern continental climates, such as Russia or eastern North America, are tempted into growth too early. Their tender shoots fall victims to late frosts, so their cultivation here is difficult, and seldom commercially worth while.

Climatic variations have important effects on British forestry. They limit the range of species which can be grown in the north-easterly and inland districts. Such trees as the Maritime and Monterey pines, and Monterey cypress, which thrive in the warm and equable climate of Devon, are out of the question for forestry further north. Even the native trees vary in the development which they attain from one part of the country to another. Thus, elm, oak and beech are at their best in the south-east. All these factors require consideration in the study and management of the forest.

CHAPTER 7

THE FLOWERS OF THE FOREST

The forest is the home of many rare and beautiful flowering plants that flourish nowhere else in the countryside. Few trees monopolise the ground entirely, but in their shade the intense competition of the open meadowland ceases. Plants of delicate structure and small size, which make but modest demands on sunlight, thrive beneath the green veil of the woodland leaves. Their life history is modified in curious and interesting ways to suit their environment.

FLOWERS OF SPRING

In late March and early April, the woodlands call irresistibly to every lover of flowering plants. For there bloom the first harbingers—pale windflowers, chaste snowdrops, and starry yellow celandines. Later come the primroses, each perfect flower of palest yellow, with its light green calyx cup, being borne on a pink stem from amidst a rosette of dark green leaves. With them appear the shy blue violets. Taller flowers follow, sometimes the dancing yellow daffodils, or the rose-red campions. Elsewhere bloom the bluebells in their myriads, each flower a delicately-modelled bell, each spike a balanced spire of graceful line, and yet the whole mass a cloud of blue mist carpeting the bare ground beneath the changing shadows of the breaking buds.

Away from the woods these plants, and the rarer kinds that grow amongst them, fade and fail, struggling to live only along the hedgerows. In some way they depend on the society of the trees, either for shade or shelter or for the decaying leaves that enrich the soil. Their spring glory is an essential part of their rhythm of growth. By coming into leaf then, before the tall trees above them, they can utilise the sunlight that throughout the summer is cut off from the forest floor. By flowering early, they attract the first spring insects and the more venturesome of the bees. Most have either bulbs or tuberous stems which store a supply of food through the winter, enabling them to spring into full flower with dramatic speed.

These flowering herbs of the woodland form plant " associations " which vary with soil and the principal species of the trees around them. They are absent from dense evergreen coniferous woods, and in beechwoods few species except the white wood sorrel survive the dense summer shade. Oakwoods have a richer flora, including bugle, sweet woodruff, and occasionally white wild garlic, dog's mercury, Solomon's seal and wood spurge. On the chalk the flora is different, but equally varied, including wild columbine, blue bell-flower, wild strawberry, and many of the orchids (4, 56, 61, 62).

CLIMBING PLANTS

Only where there are trees can the true climbing plants grow, for they rely on a tall support to raise them above the competition of lowlier herbs. Trailing shrubs such as brambles may spread over the ground, crushing down competitors, but climbers require support. Four kinds of *woody climbers*, with hard perennial stems, are found in Britain.

HONEYSUCKLE (*Lonicera periclymenum* Linn.) (139) climbs by encircling tree-trunks with its own wiry stems which gain a grip which strengthens as the tree-trunk expands. It occurs commonly in southern England. Its leaves break very early, often in January, and throughout the summer it produces clusters of delightfully fragrant pink-and-yellow tubular blossoms. But it is harmful in the forest, for its wiry stems constrict young trees, causing ugly swellings, checking the downward flow of sap, and wounding the bark so as to allow the ingress of harmful insects and fungal diseases.

Also harmful is IVY (*Hedera helix* L.) (57) which climbs mainly by gripping the bark with special short rootlets. As it can also constrict the tree by encircling it, ivy is usually cut away by the forester when it attains to too great a size. At the top of the tree, its lobed leaves are replaced by simple ones, and clusters of green flowers are succeeded by black berries.

The attractive TRAVELLERS' JOY (*Clematis vitalba* L.) (59), known also as the Wild Clematis, Old Man's Beard, or Virgin's Bower, is common in chalk districts of southern England. It trails loosely over small trees and hedges, and as it grows, the softer branches gain a grip on other plants by means of their twisted leafstalks. The white starry flowers are succeeded by tufts of hairy winged seeds.

WOODY NIGHTSHADE (*Solanum dulcamara* L.) or Bittersweet, is a smaller climber with a zig-zag stem, purple flowers, and poisonous berries, which rarely does serious harm to planted trees.

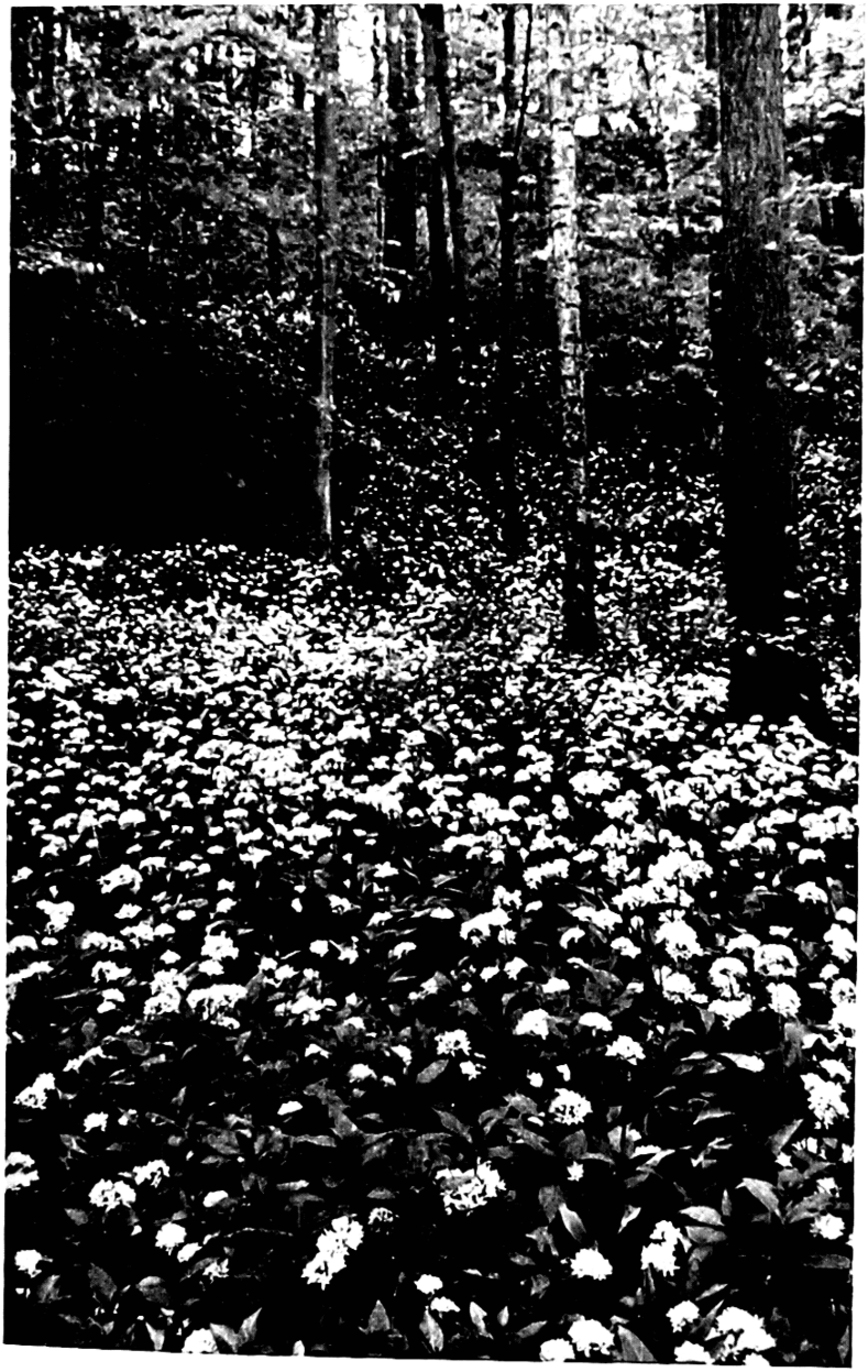
Annual climbers, which usually ascend by means of tendrils, make little headway in the forest, for the trees soon grow above their reach. Of interest are the BRYONIES, white and black, botanically distinct, but each the sole British representative of important tropical plant families (White Bryony, *Bryonia* of *Cucurbitaceae*; Black Bryony, *Tamus* of *Dioscoraceae*). The same is true of ivy (*Araliaceae*); in fact it is surprising how many of our woodland plants constitute lone outposts of more tropical vegetation.

EPIPHYTES

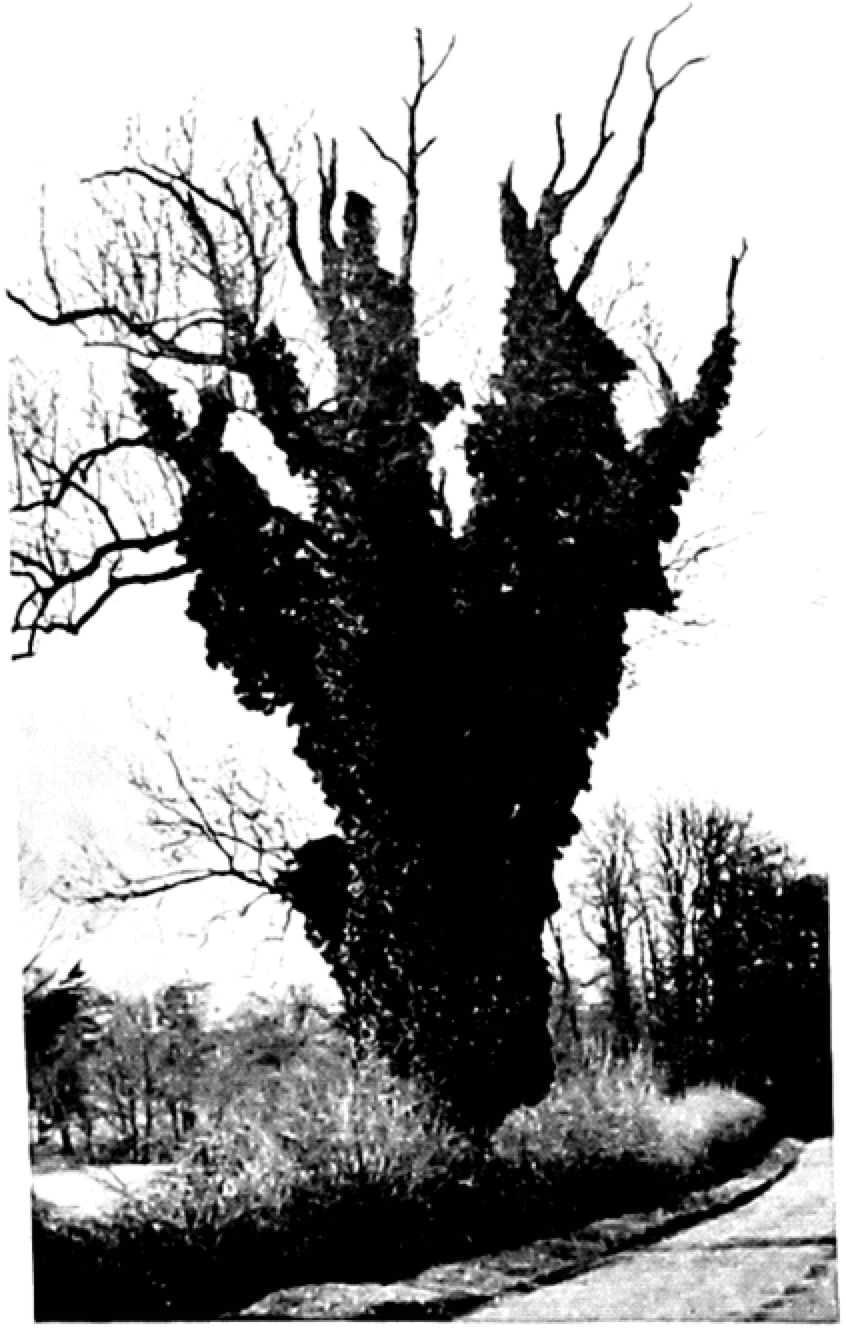
In the tropical jungles, plants known as *epiphytes*, because they grow upon other plants, usually trees, are very common. In Britain few plants have this habit except for mosses and lichens, but occasionally a giant beech will support a young hawthorn, rowan, or holly, the seed of which has been carried to a decaying fork by some bird. Our commonest epiphytic fern is the POLYPODY (*Polypodium vulgare* Linn.) found in moist oakwoods, where its evergreen leaves enliven the bareness of winter.

SAPROPHYTIC PLANTS

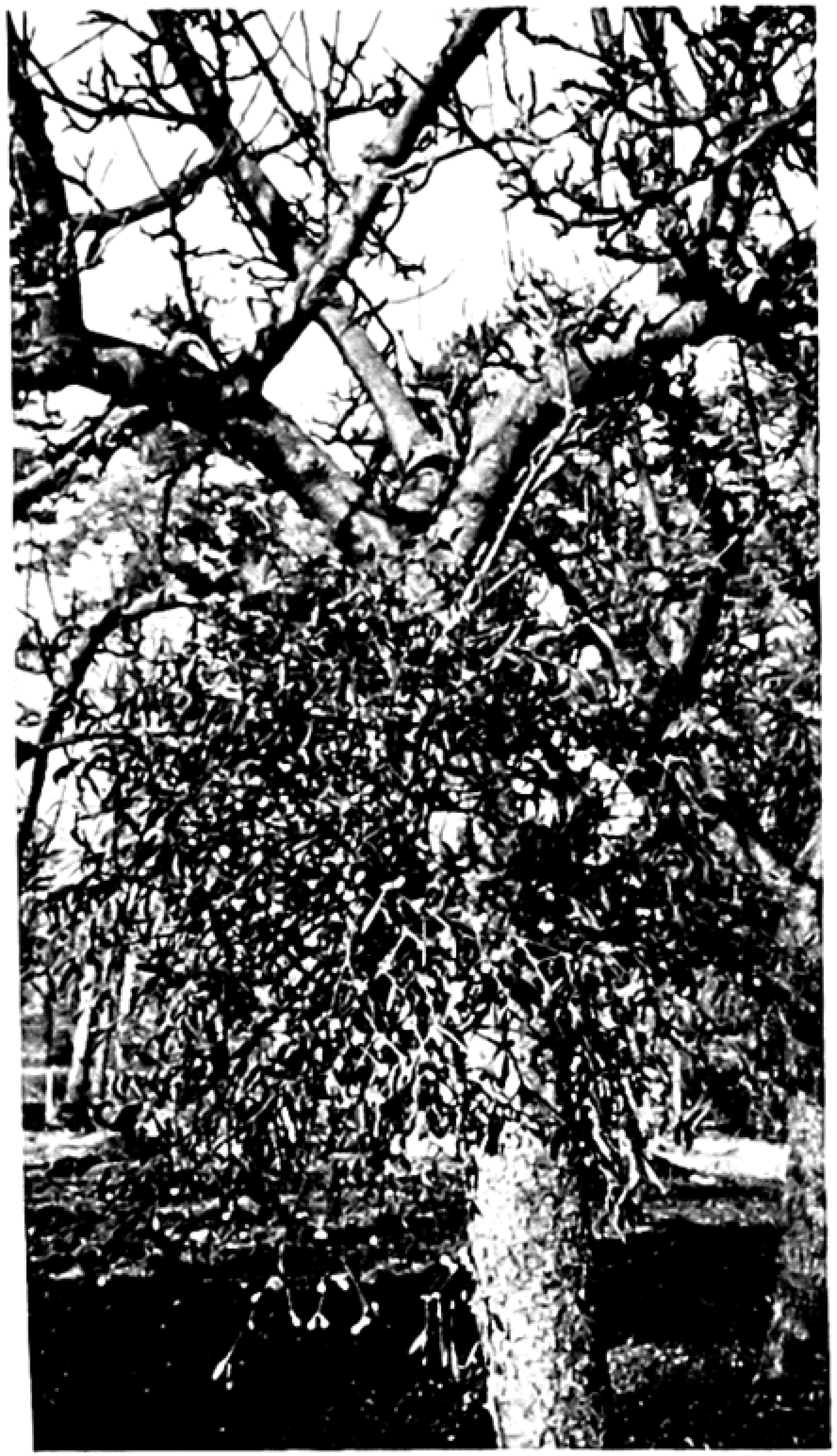
Besides producing a favourable environment, or acting as a physical support, for certain plants, trees contribute indirectly to the actual subsistence of others. The little-known group of British *saprophytic* plants derive their food supplies from the decaying humus of the woods. They do not carry on the normal nutritive process of photosynthesis, therefore their leaves lack green colouring, and are reduced to mere scales; in fact there is no green colour anywhere in these plants. They cannot themselves feed directly on the leaf-mould, but require the help of certain fungi, which live in their roots



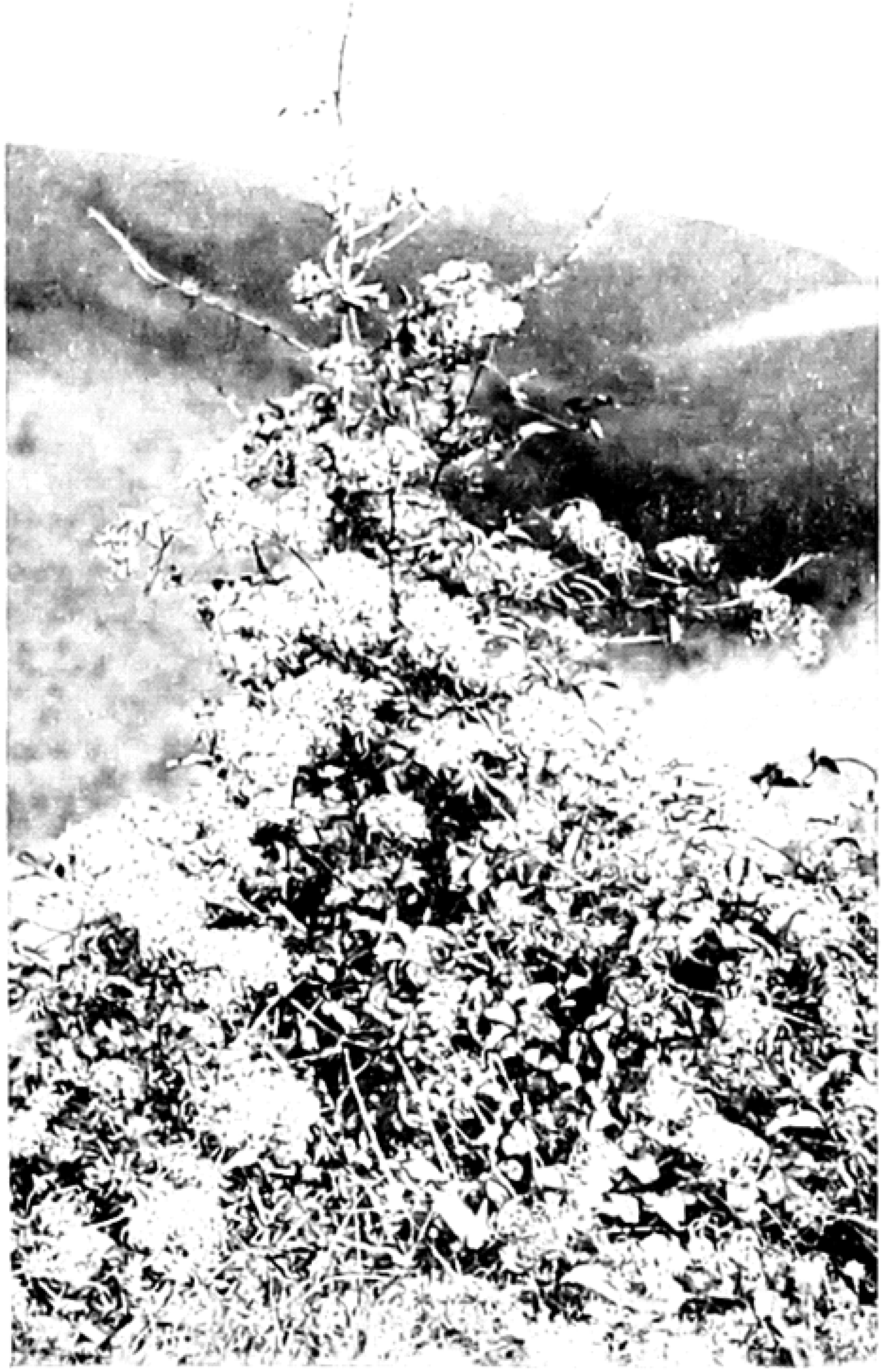
56 WILD GARLIC CARPETING THE WOODLAND FLOOR, BENEATH THE BREAKING BUDS OF APRIL



57 IVY STRANGLING AN ASH



58 MISTLETOE ON APPLE



59 TRAVELLER'S JOY SMOTHERING A YOUNG LARCH

TWO HARMFUL CLIMBERS AND A PARASITE

in a state of *symbiosis*, the combined structure of fungal threads and plant roots being termed a *mycorrhiza*.

Of this group the BIRD'S NEST (*Hypopitys monotropa* Cr.), or Fir-rape (63), occurs in beech and pine woods. Its yellow, bell-shaped flowers have five petals. It is the only British representative of the order *Monotropaceae*, and is botanically related to the heaths.

The others are all orchids, including the CORAL ROOT ORCHIS (*Corallorhiza trifida* Chat.), the BIRD'S NEST ORCHIS (*Neottia nidus-avis* Rich.), and the rare *Epipogium aphyllum* Sw. The common names of these strange plants aptly describe the tangled appearance of their mycorrhizas. They can only thrive in woodlands where humus is accumulating, chiefly dry shady areas under such trees as beech. They appear to contribute very little to the welfare of their fungus partner; in fact, they are parasitic upon it, yet also saprophytic upon the trees that provide their basic sustenance. Possibly they provide the fungus with a structural home, or assist in its distribution.

PARASITIC PLANTS

The native British flora includes a number of partial or complete parasites, but of these only three commonly attack trees. The TOOTHWORT (*Lathraea squamaria* Linn.) is a root parasite, found most often in hazel, and is allied to the BROOM-RAPES of the meadows (*Orobanchaceae*). Entirely lacking in green colouring matter, it appears as a brown flowering shoot bearing yellowish flowers. Below ground, it is believed to nourish itself in *three* extraordinary ways. Like the Bird's Nest, it is a saprophyte, feeding on humus with the aid of a fungus. But it may also be a parasite, drawing food from the hazel, and so far as is known, giving nothing in return. Finally, it is *carnivorous*, devouring minute soil animals by means of specially developed underground scale leaves.

The more familiar MISTLETOE (*Viscum album* Linn.) (58), the only British member of the important tropical family *Loranthaceae*, is a hemi-parasite on many kinds of tree, chiefly the crab-apple. The white berries are gathered by birds, which eat the pulp, and rub off the seed upon a bough. Being sticky, it adheres to the bark, and on germinating sends down a root which taps the tree's conductive tissues. The shoot develops green leaves like those of a normal plant; so the mistletoe is only partially parasitic. Indeed, being evergreen, it may assist its host tree in winter by supplying carbohydrates.

Commoner in the orchard than in the forest, the mistletoe is not a serious pest of timber trees. Growing on oak, which it does but rarely, it played a part in the druidical rites of the pagan Britons. Its popularity at Christmas probably dates back to those times.

The third tree parasite is the DODDER (*Cuscuta europaea* Linn.). This usually attacks herbaceous plants or shrubs, but has been reported on hazel, willow, and poplar. A "complete parasite," it lacks both leaves and true roots, and consists simply of a reddish climbing stem which battens upon the branches of its host plant, and draws nourishment from them. Clusters of small pretty, pink bell-shaped flowers are borne at intervals. It is not a serious pest of trees.

PLANTS AS SOIL INDICATORS

The natural vegetation of any area of ground gives a clue to the type of forest growth which it can support. The same principle is made use of by farmers, and is simply expressed in the saying: " Land that bears heather is only worth copper pennies, land that bears bracken is worth silver shillings, but land that bears gorse is worth golden guineas." In other words, the natural fertility of the soil reveals itself in the wild plant cover which it supports. Cultivated for crops, or planted with trees, the gorse land would give the most profitable results, despite the greater cost of clearing it and breaking it up.

A large number of plants form definite *associations* on the waste lands which are available for afforestation. Some, such as rushes, cotton-grass, and the CROSS-LEAVED HEATH (*Erica tetralix* Linn.), indicate damp soil conditions requiring drainage before planting can successfully be undertaken. The common LING OR HEATHER (*Calluna vulgaris* Hull.) is found on poor, acid soils, suitable for the growth of pines but too infertile for most other species.

On the poorest of soils, under heathland conditions, an *insectivorous* plant, the lowly SUNDEW (*Drosera* species) shows by its abnormal method of nutrition that the soil is hopelessly poor, for it obtains nitrogen by catching and devouring insects with its specially modified glandular leaves.

Lichens also are indicators of sterile soil conditions, inasmuch as they derive very little food from the mineral soil. They can grow on bare rocks, and their presence on any finer soil shows that it is too infertile to support more exacting forms of plant life which would overshadow and obliterate the lowly, slow-growing lichens.

Grasses, too, tell their story to those skilled in the recognition of their different species. One of the commonest is the PURPLE MOOR GRASS (*Molinia caerulea* Moench.) which grows in tussocks and indicates soil conditions suitable for spruces. The Mat grass (*Nardus stricta* Linn.) is typical of drier heaths suited to the pines; it grows in tufts and its leaves are dark green, hard-textured, and very slender. The presence of the commoner meadow grasses usually indicates highly fertile forest land.

Poor, acid, or peaty heaths and moorlands, typified by several of the plants listed above, are enormously improved for tree-planting by ploughing, which provides both drainage and aeration (132).

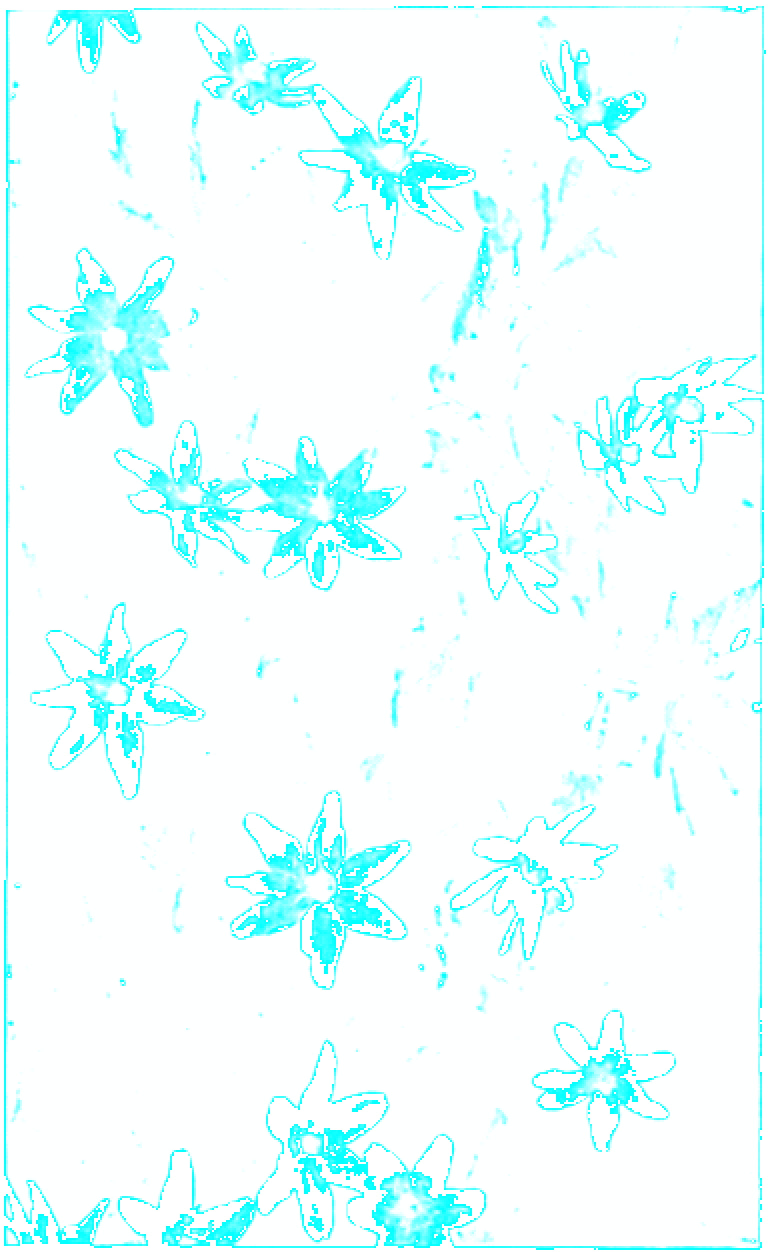
Bracken indicates better soils, suited to larches and Douglas fir. Gorse land is good, whilst meadows or old arable land will usually support broad-leaved trees as well as conifers. Certain plants such as the Rock Rose (*Helianthemum* species) indicate soils rich in lime, and therefore well suited to the ash and the beech. Others, such as bluebell, foxglove, and willow herb, continue to frequent former woodland for some years after felling, and indicate the presence of a fertile forest soil suitable for re-planting (64, 65).

WEEDS

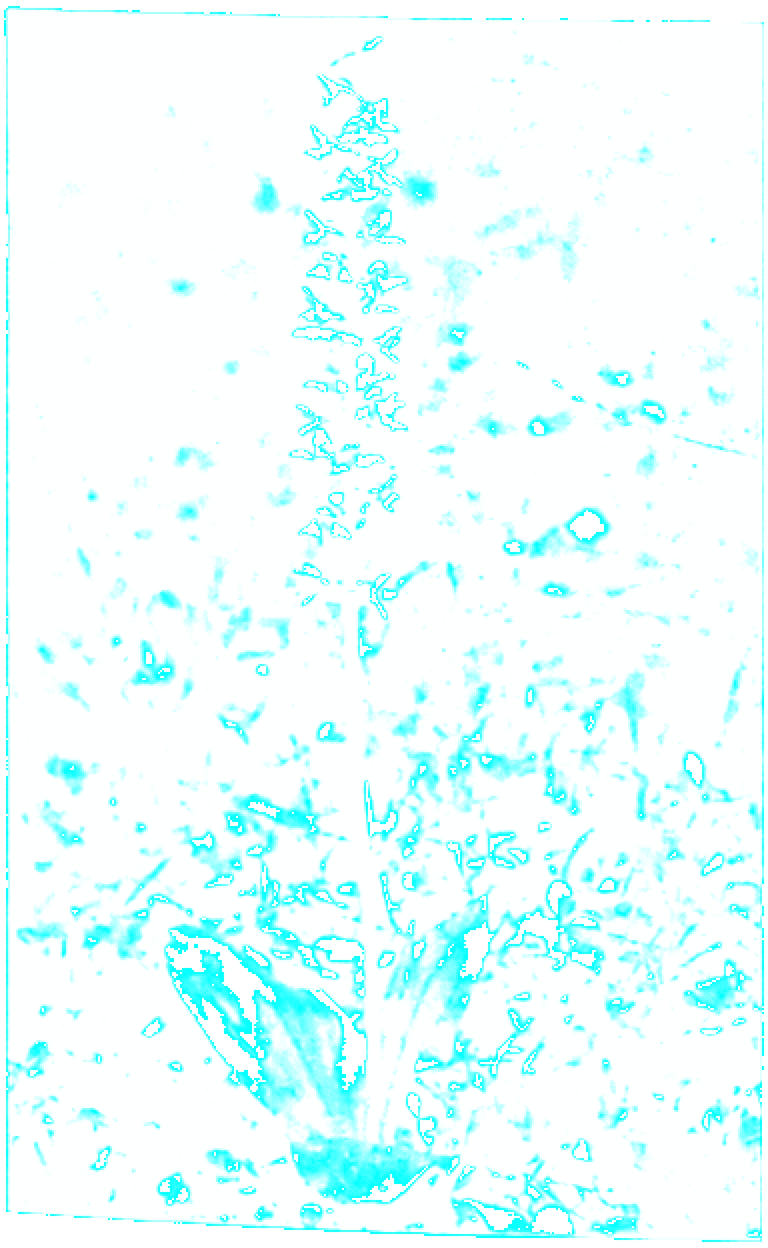
After a plantation has been made, the natural vegetation competes more or less strongly with the young trees, and some plants do serious damage unless checked. It pays the forester to watch closely the cycle of growth of each wild plant. For it is unprofitable to cut back short grasses, bluebell, etc., which cannot damage the trees at any stage; whereas bracken, which casts a heavy shade in summer and falls as it fades in autumn, may smother a whole tree crop, and must therefore be rigorously cut back for several seasons.

Certain types of soil cover, such as heather and Blue Moor grass, are highly

60 CHICKWEED WINTERGREEN, *TRIENTALIS EUROPASA*



61 WINDFLOWER, *ANEMONE NEMOROSA*



62 BUTTERFLY ORCHID, *HABENARIA BIFOLIA*

63 BIRD'S NEST, *HYPOPITYS MONOTROPA*

CHASTE AND CURIOUS WOODLAND FLOWERS

64 ROSE-BAY WILLOW HERB, *EPILOBIUM ANGUSTIFOLIUM*

65 FOXGLOVE, *DIGITALIS PURPUREA*

INDICATORS OF FERTILE WOODLAND SOILS

inflammable, and add to fire risk in the young plantings. This risk is lessened if they are checked or smothered by a preliminary ploughing of the land. Others, such as short succulent grasses and soft herbs, tend to lessen fire danger.

Shrubs and trees occasionally rank as weeds in plantations; particularly when they take the form of coppice growth springing up from the stumps of a former tree crop.

GROUND FLORA

Beneath the leafy canopy of the full-grown forest, there occurs a lesser soil covering of lowlier plants termed the *ground flora*. This varies with both soil and tree species, and also with the density of the wood's growing stock, and with the amount of light which reaches the forest floor. Beneath light-demanding trees such as pine and birch, bracken is frequently found, whereas the shade of spruce or beech would suppress it. Too vigorous a growth of ground flora indicates that the ground is carrying too light a tree crop.

Many plants of the open meadows are absent from the shade of forest trees; being light demanders themselves, they cannot play a subordinate part. For example, very few plants of the Pea family (*Leguminosae*) can thrive without full sunlight, and the Daisy family (*Compositae*) are also scarce in the woods. The spring-flowering plants discussed earlier in this chapter are typical representatives of the ground flora of the woodlands.

GRASSES, FERNS, AND MOSSES

The majority of grasses shun the grown woodland, but some are adapted to life in the half-light. Several genera contain species which prefer a forest habitat, and can seldom be found in the open. The Soft grass (*Holcus mollis* L.) forms ground cover in dry oakwoods, whilst the Wood Melic grass (*Melica uniflora* Retz.) is typical of damper situations. One of the largest and most elegant of our grasses is the Millet grass (*Milium effusum* L.) which throws up loose panicles of flowers to a height of four feet on the fringes of moist broadleaved woodlands; its seeds form a favourite food of wild birds, especially finches.

The woodland is rich in ferns, for the moist conditions favour the development of the delicate *prothallium* stage of their life history. Commonest is the Bracken (*Pteris aquilina* L.) with its creeping underground stem. It is very persistent, and though often suppressed by the dense overhead shade of a young plantation, usually reappears when the crop opens up.

Other large and handsome woodland ferns are the Male fern (*Dryopteris filix-mas* Schott.), and the Lady fern (*Athyrium filix-foemina* Roth.). The Hart's Tongue (*Phyllitis scolopendrium* Newm.), found in moist lowland woods, is remarkable for its strap-shaped, undivided frond, which is evergreen. Another common evergreen is the Hard fern (*Blechnum spicant* With.), which bears ladder-like, erect fertile fronds in summer (68, 69).

Horsetails are represented by the Wood horsetail (*Equisetum sylvaticum* L.), found in the damper zones of peaty-soiled woods.

Mosses are frequent in the woods, forming a soft green carpet to the forest floor, and many species are useful as indicators of the state of the soil. Their simple structure enables them to thrive under " marginal " conditions which higher plants cannot tolerate. Thus they occur in deep shade on moist, peaty soil consisting mainly of humus; and on such sites they can persist long after those trees which originally formed the peaty mould have disappeared (67). Their allies the Liverworts also occur in moist woods.

Epiphytic mosses, which grow upon tree trunks in moist situations, include the Feather moss (*Eurhynchium* species). Certain ground mosses prove important in afforestation work insofar as they modify the surface layers of the soil. The commonest of these is the Bog moss (*Sphagnum*), which builds up dense layers of peat on damp moorlands.

This short survey of the British woodland flora gives only a general idea of its interest and complexity. Without the trees, hundreds of rare species could not thrive in this country. In the woods alone do they find shelter, support, nutriment, or the moist shady conditions which they love. No two areas of woodland are the same in their floor-covering of flowers, and curious new associations of tree, herb, grass, and moss, arise wherever plantations are formed with foreign tree species. Many flowers of the woods are of great natural beauty. Their shady surroundings impose on them a delicacy of flower and leaf not to be found in the open fields. This is revealed by the general sparseness of the vegetation, and enhanced by the ever-changing green canopy of foliage that waves above them (60–63, 67).

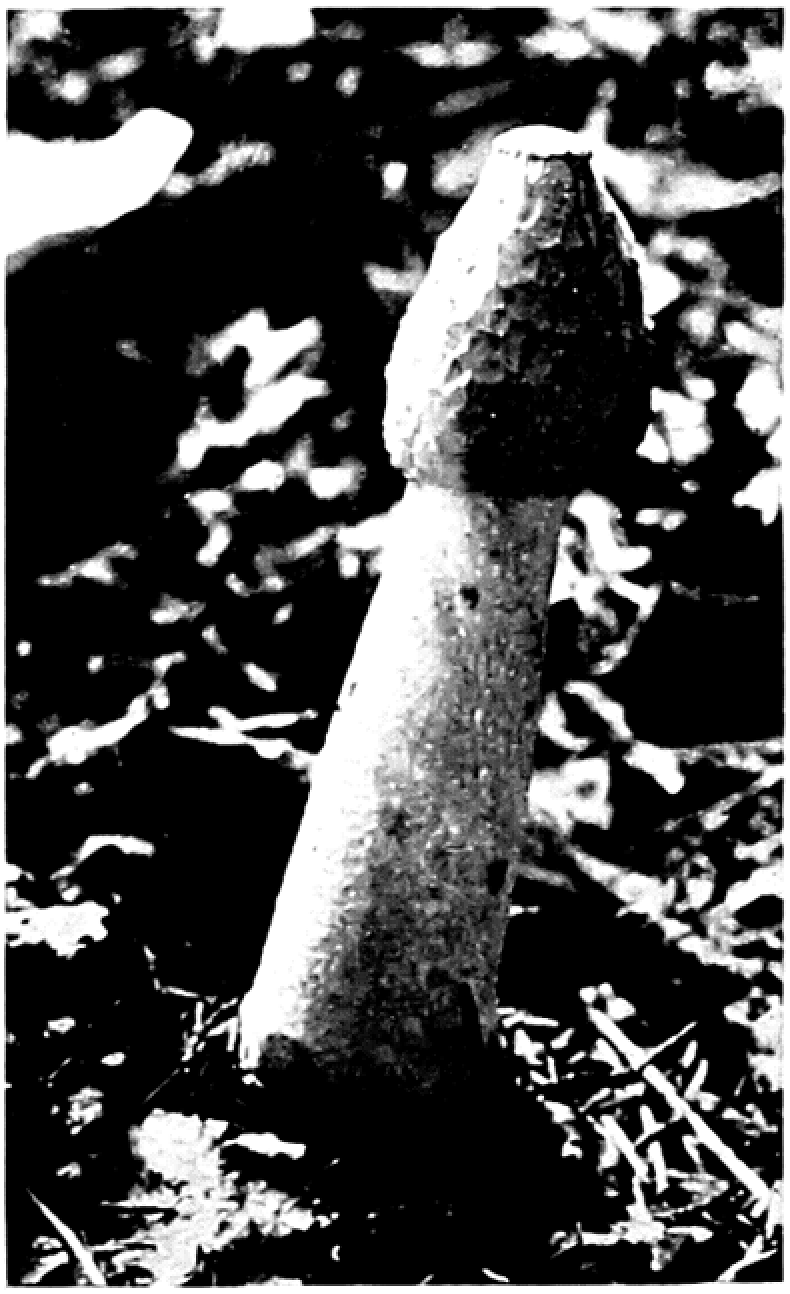
66 LICHENS OF SEVERAL SPECIES ON AN OAK BOUGH

67 PENNYWORT, WOOD SORREL, VIOLET, FERNS AND MOSSES

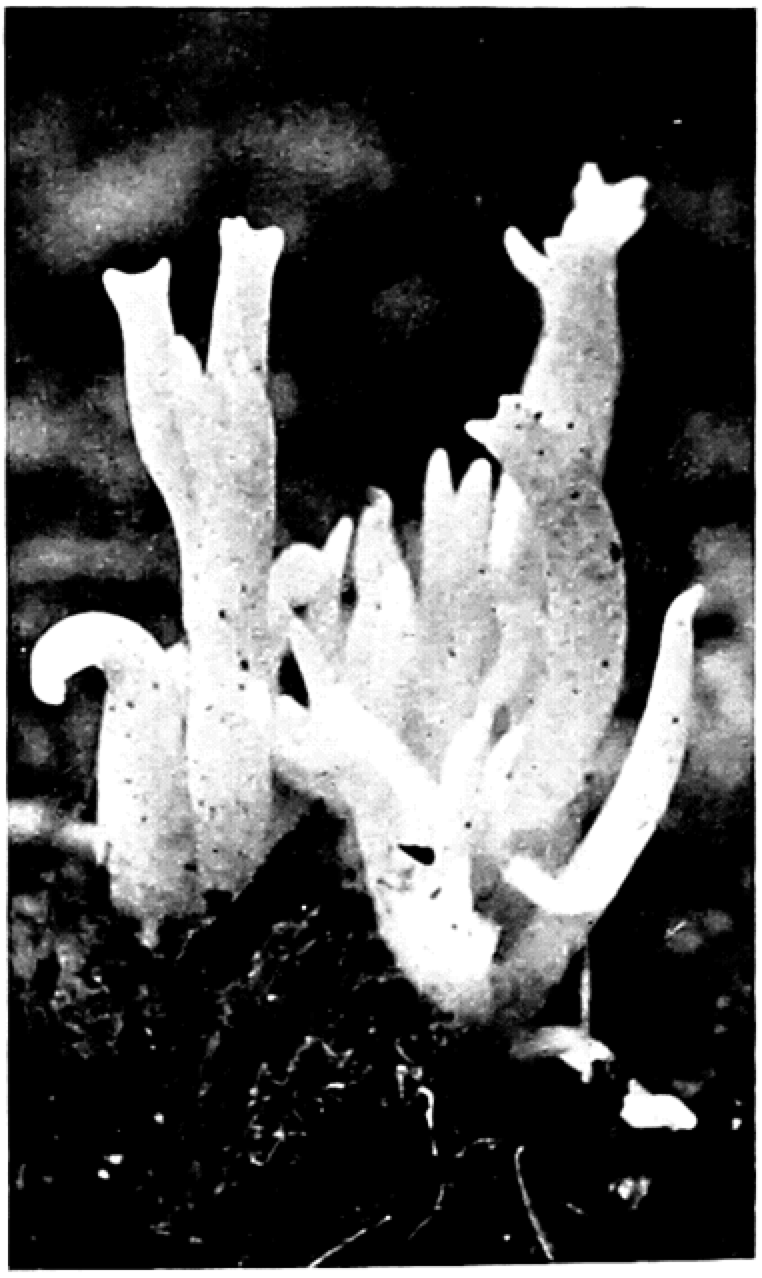
68 MAIDENHAIR SPLEENWORT, *ASPLENIUM TRICHOMANES*

69 HARD FERN, *BLECHNUM SPICANT*

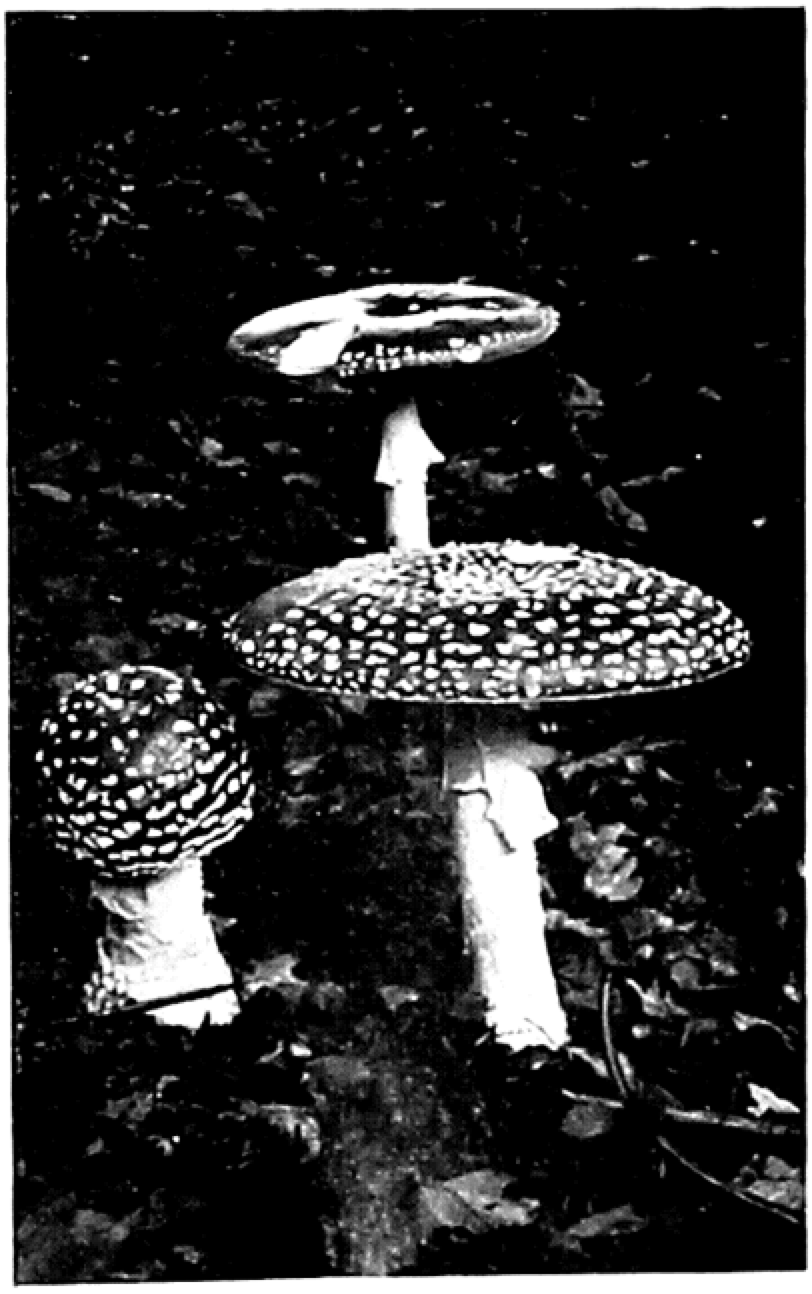
INTRICATE ASSOCIATIONS OF LESSER WOODLAND PLANTS



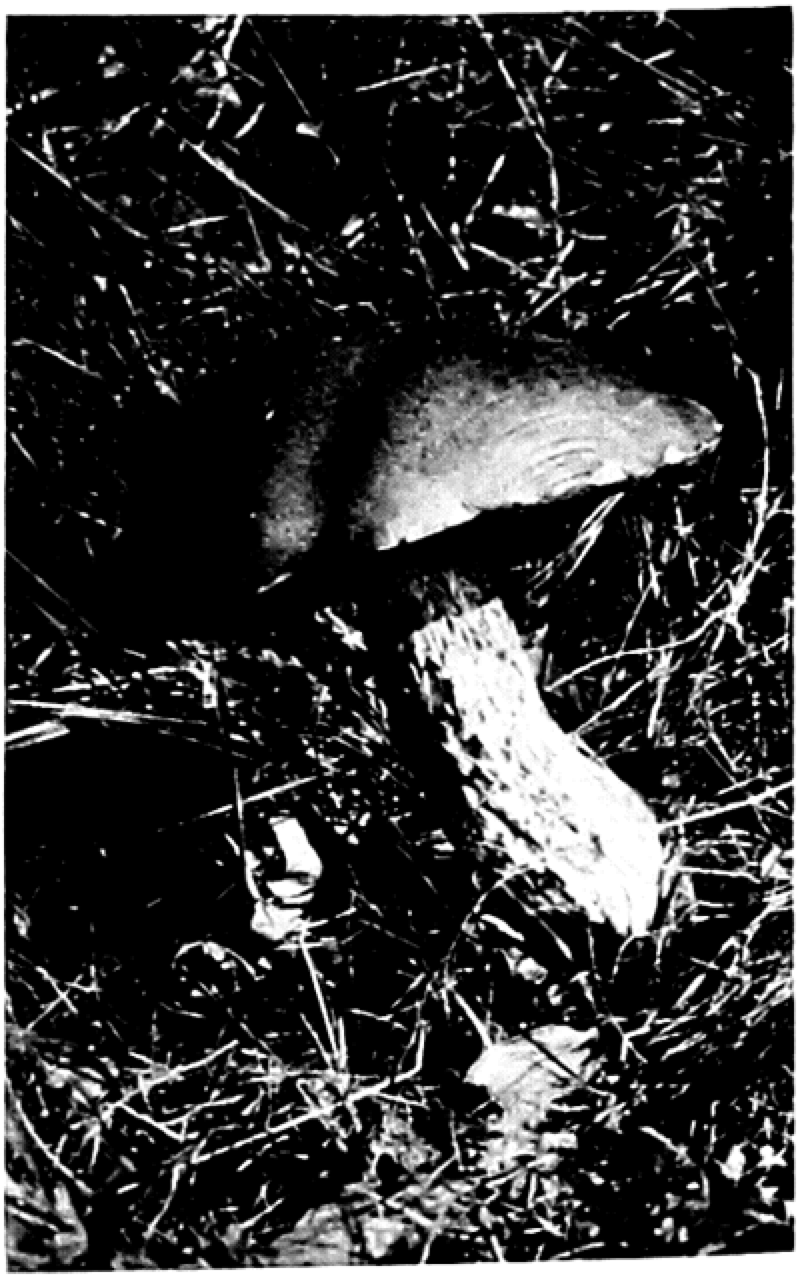
70 STINKHORN, *PHALLUS IMPUDICUS*



71 FAIRY'S CLUB, *CLAVARIA AUREA*



72 SCARLET FLYCAP, *AMANITA MUSCARIA*



73 COW BOLETUS, *BOLETUS BOVINUS*

REMARKABLE WOODLAND FUNGI

CHAPTER 8

FOREST FUNGI AND TREE DISEASES

Fungi are of singular importance in the woodlands. They are simple plants adapted to live on organic matter. Lacking chlorophyll, they cannot obtain their carbohydrates from the air, and must perforce feed upon living or dead vegetable or animal substance. Therefore they lack both leaves and roots, and consist mainly of thin filamentous stems called *hyphae*. Although they do not need light for their existence, they are dependent, like other plants, on a steady supply of air and water, and cannot live where these are lacking.

Fungi reproduce themselves by means of minute air-borne spores, which are produced in structures called *sporophores*. These are often large, complex, conspicuous structures, which draw our attention to the existence of the fungus and enable it to be identified. But they are not developed until the hyphae which support them have spread extensively through the food medium, so that they do not reveal the presence of a harmful fungus until the damage has been done. In Britain they are commonest about September, for many fungi, like most higher plants, fruit at the close of their annual growing season. The common mushroom is the sporophore of a fungus which feeds on dung.

The greatest natural accumulation of organic matter, the food of the fungi, occurs in the forest. Here, therefore, we find the greatest range of species and a wide variety of modes of nutrition. Many fungi confine their attentions to dead plant matter, and obtain their nutriment by breaking it up. These are harmless to other plants, and may indeed help them by liberating the nutriment stored up in the humus. But others are dangerous parasites, and prey upon tree stems, leaves, and roots, frequently bringing about the death of the trees which they attack. From the forester's view-point, these can be regarded as the causative organisms of tree diseases. The classification of fungi depends on a microscopical examination of their sporophores, but many kinds may be recognised by their distinctive form, or by the damage they do to specific trees. The study of the group forms a special branch of botany termed *mycology*.

ROT AND DECAY

The *saprophytic* fungi, feeders on dead plant matter, are indispensable agents in the break-up of fallen leaves, branches, and trunks. On the forest floor they find congenial conditions of air and moisture, and rapidly convert dead timber into fertile organic soil matter. The species are very numerous, and whilst some are catholic in their tastes and attack wood of many varieties, others feed on the tissues of certain trees only. Thus the Fir-cone fungus (*Hydnum auriscalpium* L.) grows only on old fallen cones, bringing about their decay; it bears curious one-sided toadstool-like sporophores.

Most conspicuous of this group is the SCARLET FLYCAP (*Amanita muscaria* Fr.), which shows a preference for birch woods. It bears a brilliant scarlet mushroom-shaped head upon a white stalk. The scarlet surface is frequently flecked with white, and this vividly coloured toadstool sometimes appears in fanciful paintings as a pixy's seat. It is deadly poisonous (72).

Conspicuous to the nose, although less so to the eye, is the aptly named STINKHORN (*Phallus impudicus* Grev.) (70). A dweller in moist conifer plantations where dead needles and branches accumulate thickly, it bears a columnar sporophore with an expanded, sticky, and fleshy tip. Its powerful stench recalls decaying flesh, as indeed it is intended to do, for it serves to attract the flies which distribute the spores.

Timber left lying in the woods after felling, is attacked by a variety of saprophytic fungi. The same applies to timber carelessly stacked in the timber yard, and to any woodwork which subsequently becomes exposed to damp conditions without the exclusion of air. The well known DRY ROT is caused by the fungus *Merulius lacrymans* Schum., but it needs moisture like other fungi, though much less than most, and occurs chiefly in very old or defective buildings. Timber rot is most serious at or near ground level. Above ground, the fungi of decay can seldom obtain sufficient moisture; below ground, they lack sufficient air.

THE PRESERVATION OF TIMBER. Many timbers contain natural organic substances which enable them to resist decay, though these are often confined to their heartwood. In hardwoods, such as oak and sweet chestnut, *tannins* occur. In most conifers, *resins* are common. Similar substances can be impregnated into perishable timbers by artificial means. The commonest of these is *creosote*, an organic liquid which can be obtained from timber itself, but is more usually distilled from coal tar. Creosote may be applied with a brush or spray, or small articles such as fence posts may be first heated whilst standing in an open tank of the hot liquid and then allowed to cool, so that they absorb the creosote whilst cooling. For important work, such as telegraph poles, the timbers are first barked, then scored at intervals by cutting incisions in their surface, and then heated in creosote in a closed iron vessel under air pressure which forces the preservative liquid deep into their tissues.

TREE SURGERY. Where the heartwood of a standing tree is attacked by saprophytic fungi, so that the stability of the outer, still living sapwood is threatened, the life of the tree may be prolonged by a form of surgical operation. If the decaying wood is cut away, the adjoining sound wood disinfected and the trunk strengthened with concrete filling or metal braces, the tree may be saved from disaster for many years. But this process, useful as it is in the case of ornamental trees, is of no value in forest practice. In the forest, a decaying tree must be felled before the rot spreads too far, the sound timber saved, and the rest abandoned as a loss.

SYMBIOTIC FUNGI AND MYCORRHIZA

We have seen how the saprophytic fungi break up the humus covering of the forest soil into a condition in which it forms a nourishing medium for tree roots. They therefore aid in the nutrition of the main tree crop. It is not surprising, therefore, to find that many tree roots live in close association with them, forming a combined structure of tree root and fungal hypha which is termed a *mycorrhiza*. This may be seen as short stumpy outgrowths on the roots of certain conifers, though the finer detail of the combined structure is invisible to the naked eye.

Little is known concerning the interrelations of tree and fungus in this arrangement. The fungus is not a parasite upon the tree, since it does not damage it, and is found to stimulate rather than to retard its growth. It is evidently a case of *symbiosis* or the living together of different organisms to their mutual advantage. Either can live apart from the other, but by working together, both benefit.

The tree partner is well fitted to elaborate, in sunlight, carbohydrates and similar organic substances, and it may be that at times it supplies a surplus of these to the fungus, particularly at its spore-bearing stage. The fungus, working in the dark, can possibly obtain both water and mineral nutrients in excess of its requirements, and pass a portion of them on to the tree. From the presence of the tree it also obtains a favourable environment, and a constant supply of fresh humus in the form of falling leaves.

Various species of fungi form mycorrhizal associations with various trees. The cow BOLETUS (*Boletus bovinus* L.) (73), which occurs on Scots pine roots, produces buff coloured fructifications covered with a sticky mass of mucus. These sporophores appear as a rule about September. They resemble mushrooms, and are edible, though hardly an attractive meal. *Boletus luteus* L., an allied species, forms mycorrhizal associations with both pine and birch, whilst the Scarlet Flycap (*Amanita*), is believed to combine with the birch as a symbiote, besides at times living as a saprophyte, as mentioned above.

Mycorrhiza are commonly found in all forest soils, and take care of themselves in such environments, with little or no assistance from the forester. But exceptionally, their absence may limit the vigour of tree growth. Thus, when pine seeds of various species were exported to East Africa, the requisite fungi were lacking, and healthy trees could not be grown until these were imported also. Even in Britain, where seed of conifers is sown on *new* nursery ground, growth is generally unsatisfactory. It is therefore the practice to use new ground for transplants before conifer seed is sown on it, as in this way it becomes inoculated with the fungi required.

Soil conditions which check fungi, such as lack of aeration or the presence of sulphur compounds, also restrict the growth of the forest trees which rely upon them for a part of their nutriment. Ploughing of difficult soils, by admitting more air and improving drainage, stimulates the growth of beneficent fungi; for they, like higher plants, need air in the soil if they are to thrive. Therefore, ploughing aids both partners in the tree-fungus combination, and its good effects are intensified accordingly.

Other groups of plants form mycorrhiza, in particular the orchids and the Heaths, both frequently peat dwellers. The importance of the structure in the forest is that it enables the trees to grow, to some extent at least, on their own humus. This means that good timber may be raised repeatedly on poor soils without the exhaustion that would occur with farm crops.

PARASITIC FUNGI

A host of fungal pests attack trees of all kinds at all stages. Some are saprophytes which assume the parasitic habit in suitable circumstances; others are *obligate* parasites, obliged to feed on living tissues. Leaf, stem, trunk and root are alike liable to attack, even seeds are not immune. Fortunately few fungi are able to bring about the downfall of a healthy tree. Some merely weaken it in some slight degree, and many others only kill it when it is growing in unfavourable surroundings or is nearing the end of its normal life-span.

Thus, of 27 kinds of fungus known to attack the Scots pine, only 7 rank as serious pests, and despite these the tree continues to flourish both under cultivation and in the wild state. 14 fungi have been found on the elm, (75, 78), but only one, the Dutch Elm Disease (*Ceratostomella ulmi* Buisman), spread by the agency of a bark beetle, proves a serious factor in the cultivation of this tree. Therefore, whilst the mycologist finds ample material for study in the fungal parasites of forest trees, the forester is concerned with comparatively few serious tree diseases.

MILDEW AND DAMPING-OFF. In their seedling stage trees suffer from the mildew diseases caused by fungi of simple structure, many of which also attack herbaceous plants. The name " mildew," literally " mealy dew," aptly describes the dusty appearance of the attacked plants. OAK MILDEW (*Microsphaera alni* Wallr. var. *quercina*) covers oak seedlings with a white dust, and severely weakens them in damp summers.

More serious, though less conspicuous, damage is done by the DAMPING-OFF FUNGUS (*Phytophthora omnivora* De Bary) which may kill seedlings by the thousand in damp or over-shaded seedbeds. Fortunately, in the nursery the forester can combat fungal attack by chemical means, such as sulphur sprays.

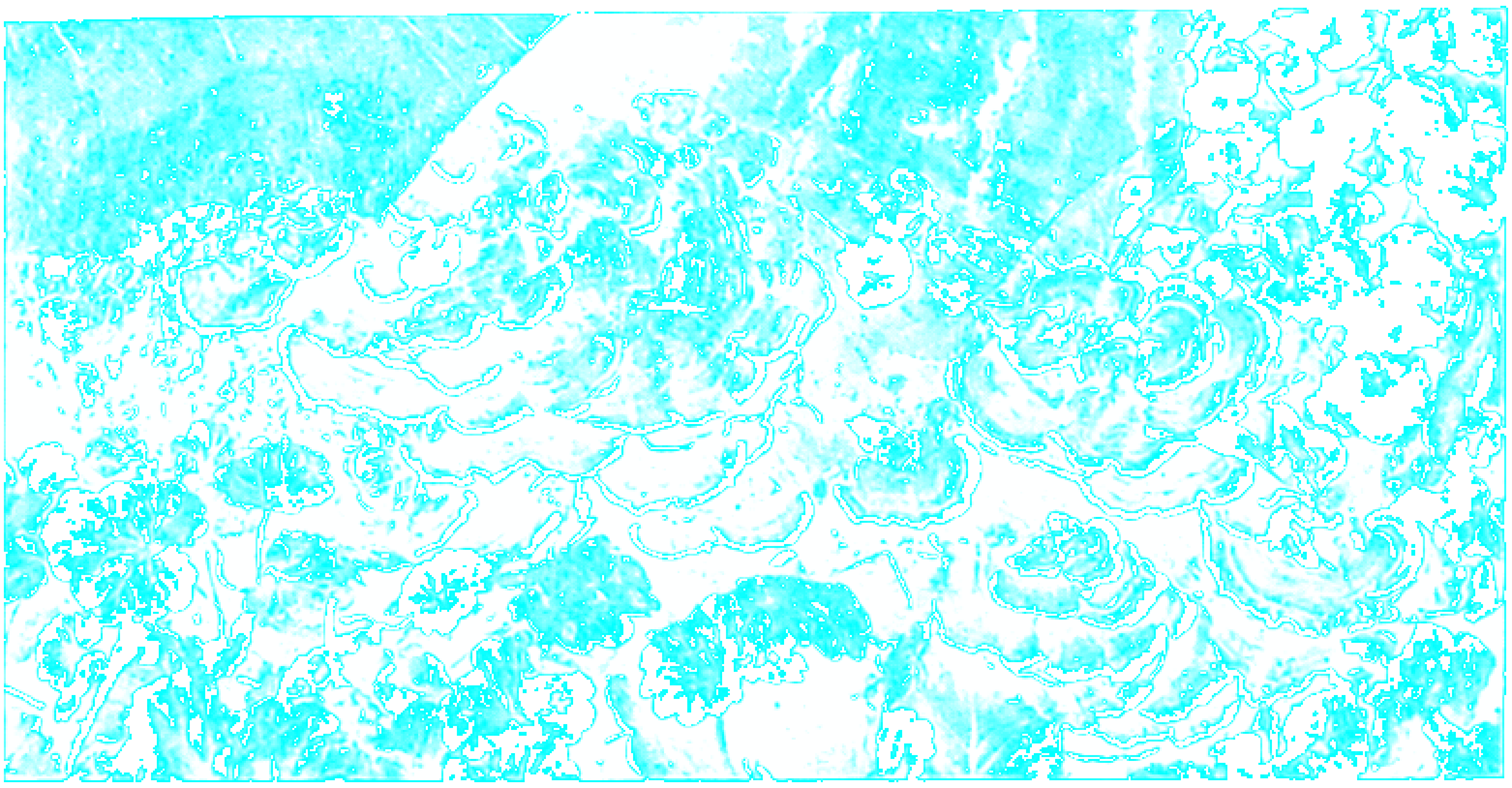
LEAF DISEASES. Certain minute fungi specialise in attacking the needles of conifers, causing needle cast. *Lophodermium* is the principal genus, and it does most damage when it attacks young trees in the nursery, but well-nourished trees in good soil seldom suffer severely.

On the sycamore leaf, the BLACK SPOT DISEASE (*Rhytisma acerinum* Pers.) is conspicuous but does little damage. Such leaf diseases can be controlled to some extent by chemical sprays—that is, in the nursery, or where a few valuable specimen trees only are affected. But when large areas of forest are attacked, no control measures can usefully be applied.

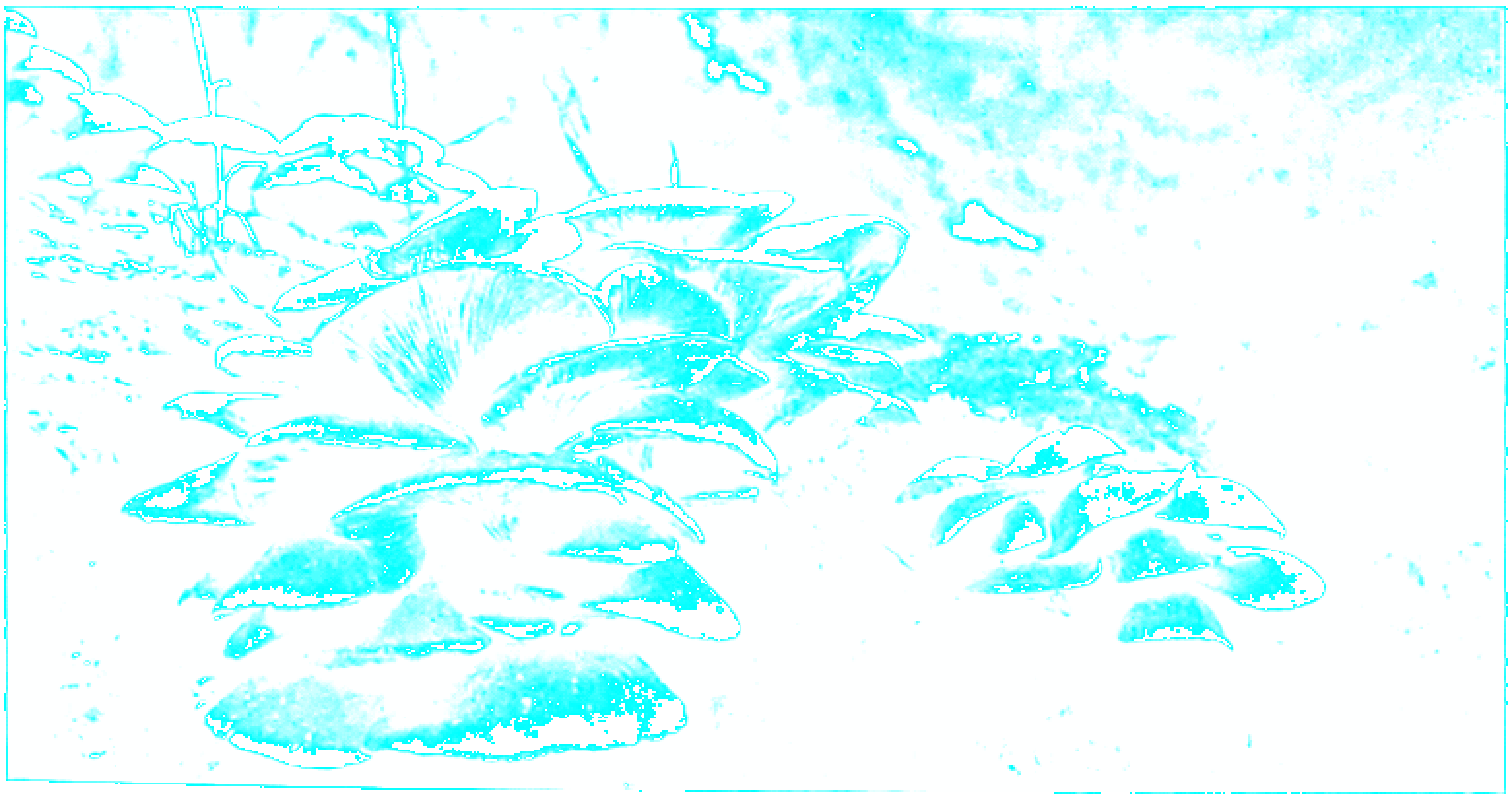
WITCHES BROOMS. On many trees, particularly broadleaves, curious clusters of densely interwoven twigs occur, like some fantastic bird's nest. These are termed " Witches Brooms," and though this abnormal growth may arise in various ways, as by insect attack, it is frequently caused by fungi of the genus *Taphrina*. Birches are often attacked.

CANKERS. Many fungi attack the stems of trees, causing cankers. Their spores gain entry through some wound or crevice in the bark, and a typical open sore in the side of the stem results. The tree usually fails to heal the damage for many years, and growth at the point attacked is one-sided, causing flaws in the resulting timber. The genus *Nectria* commonly attacks beech and ash, and affected branches bear small rounded fruiting bodies of a bright pale reddish hue. The best preventive measure is to cut away the affected branches with sterilised tools, and burn them.

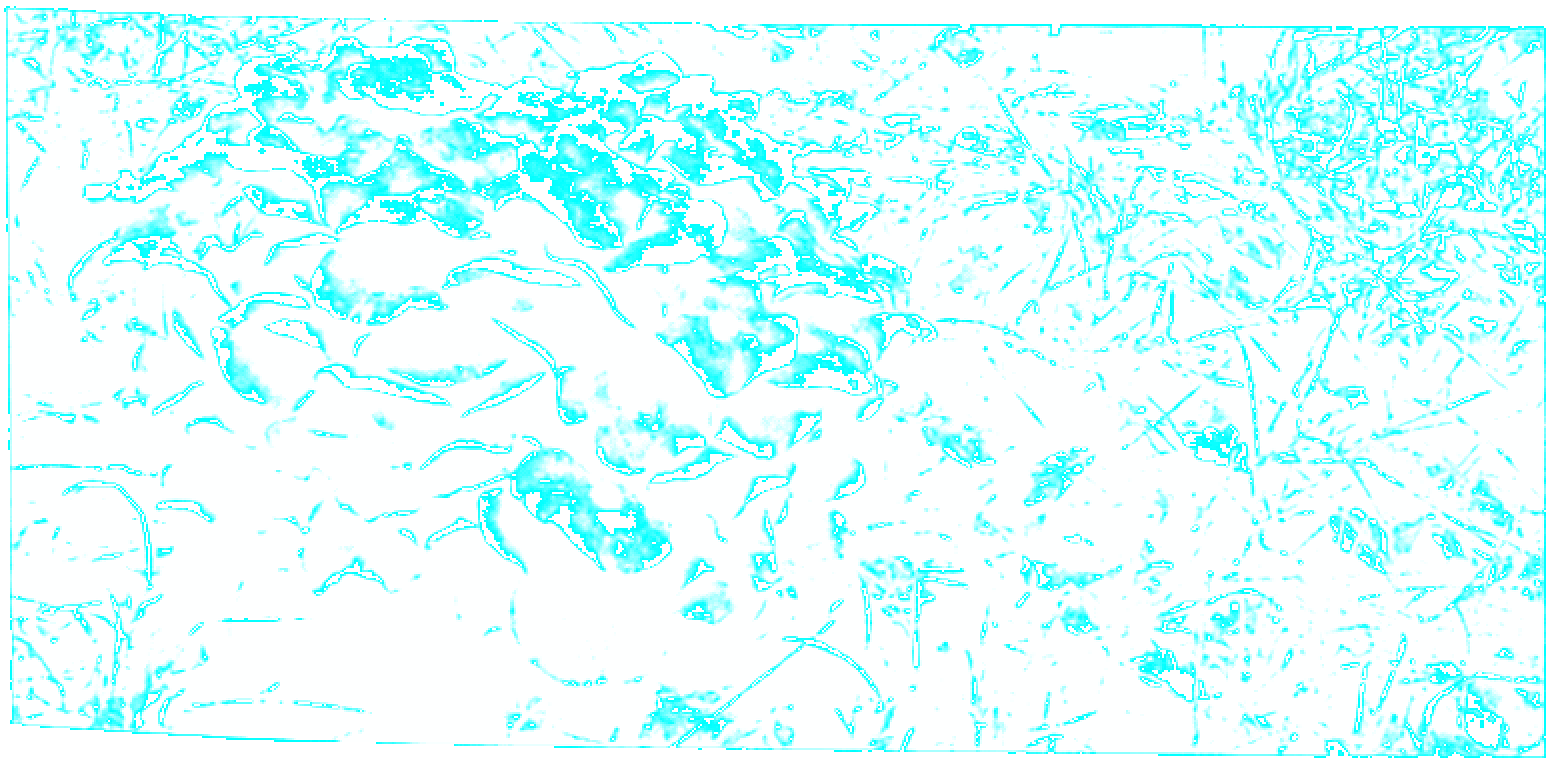
Of this group the LARCH CANKER (*Dasycypha willkommi* Hartig) is important economically and interesting on account of the means taken to restrict the harm that it does. It attacks the European larch, chiefly young trees of ten to twenty years of age, and though it does not always kill the tree it greatly weakens it and causes grave defects in the timber. Gaining entry through some trivial wound, often caused by frost, it causes an ugly open wound over half the circumference of the tree trunk, which eventually bears its tiny cup-shaped fructifications.



74 *STEREUM PURPUREUM*, SAPROPHYTIC ON BIRCH, ETC.

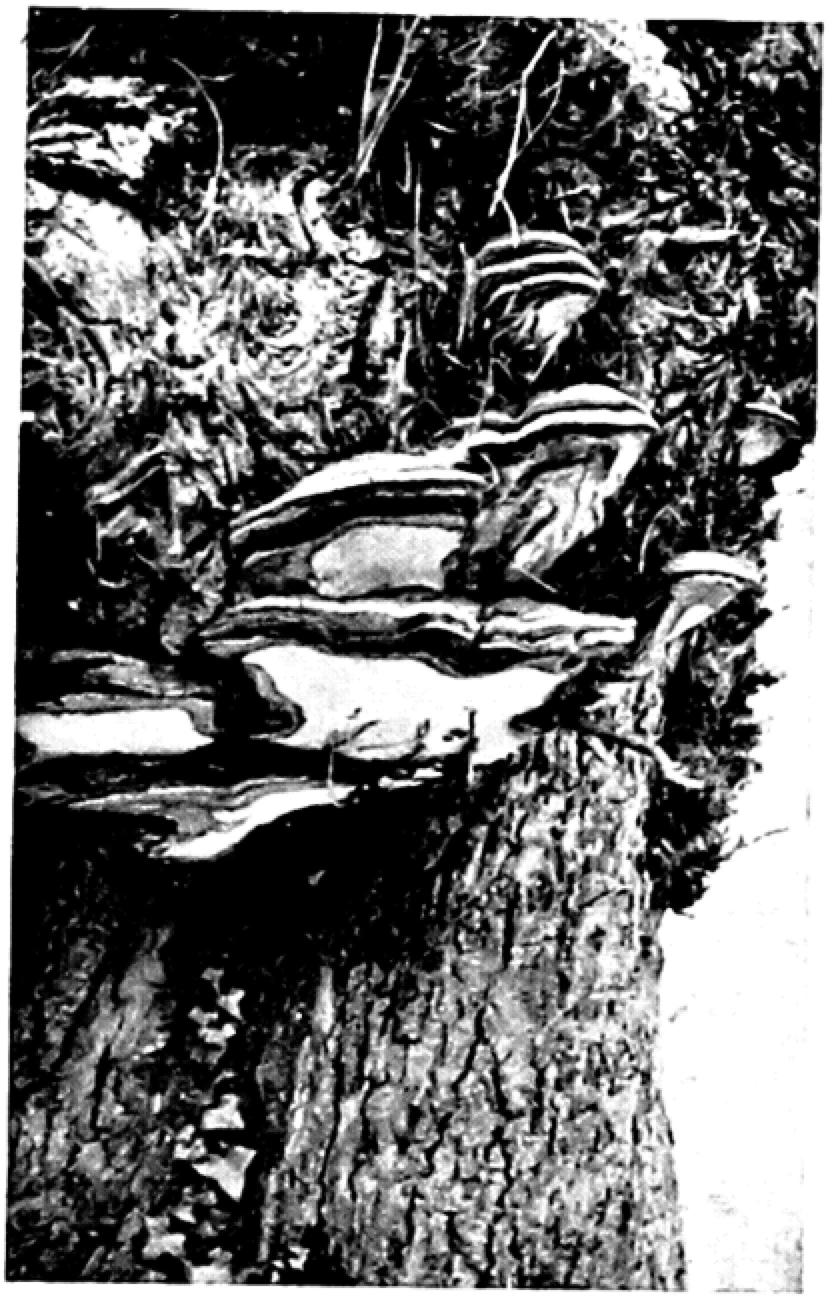


75 *PLEUROTUS ULMARIA*, A SAPROPHYTE OR PARASITE OF ELM

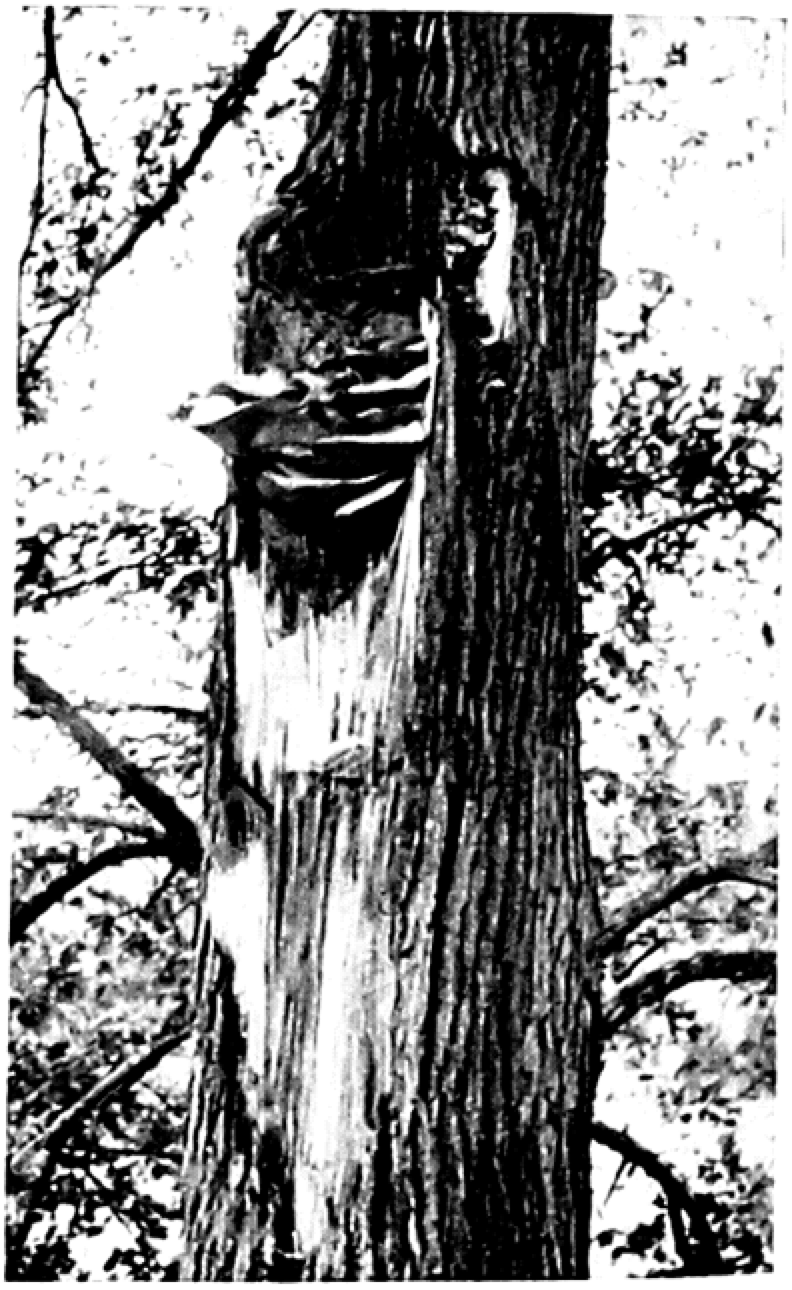


76 *AGARICUS MELLEUS*, A DANGEROUS PARASITE OF YOUNG CONIFERS

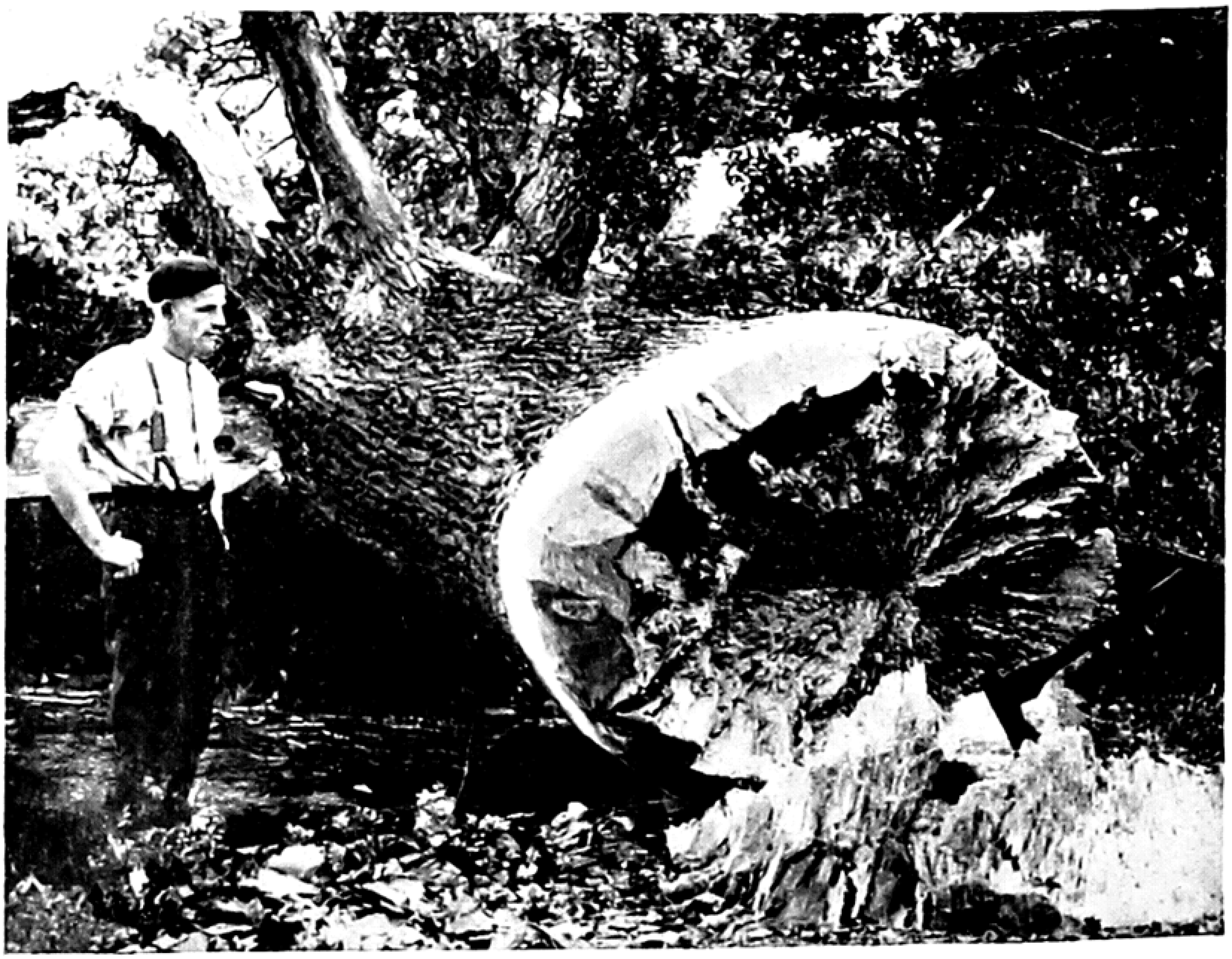
FRUCTIFICATIONS OF COMMON WOODLAND FUNGI



77 *FOMES APPLANATUS* ON ASH



78 *POLYPORUS SQUAMOSUS* ON ELM



79 OAK TRUNK ROTTED BY *POLYPORUS DRYADEUS*

BRACKET FUNGI AND THEIR WORK

In the alpine homeland of the larch, this canker does little damage, as conditions seldom favour its spread. It bears its spores in the spring, which is of short duration as an active period of tree growth; and even-aged plantations of larch are rare there. But in Britain and the lowlands of Europe, the longer, milder, spring growing season suits it admirably, as did the extensive areas of pure even-aged larch woods which were planted at the time when fashion favoured this species above all others. On the forestal scale, no counter-measures are possible, and so serious was the damage that at one time it looked as though the cultivation of the larch, most valued of conifers, must be given up throughout Britain. The situation has been improved, however, by new strains of larches and better methods of planting.

Thus, larch seed is now obtained from Scottish plantations, or imported from the lowland areas instead of from the higher Alpine zones; or the Japanese larch, better adapted to our maritime climate, is planted instead. The damage may be greatly restricted by interplanting the larch with another species, which forms a basic reason for the larch-Scots pine mixture which is popular in Scotland.

RUST FUNGI. These are remarkable for their complex life history. They produce two or even three types of spores at different stages and attack two different kinds of plant alternately. Of forest importance is the WEYMOUTH PINE RUST (*Cronartium ribicola* DIETR.), or Blister rust, whose alternate host plant is the garden currant or gooseberry. As the Weymouth pine is usually planted in Britain in ornamental grounds near gardens where currants are grown, the rust fungus prospers accordingly. Attempts have been made to find another five-needled pine, resistant to the fungus, to replace it for forest planting. A similar rust named *Peridermium pini* attacks other species of pine, mainly where thinnings are neglected, causing damage to timber, but its life history is incompletely known.

ROOT PARASITES. Thus far we have dealt with fungal parasites that attack the aerial portions of the tree, where their devastations can easily be seen. More dangerous, more insidious, are those which work at the roots, unseen and often unsuspected until an apparently healthy tree is overturned by the winds or until the tree-feller reveals rot stretching far up an otherwise sound and valuable log (79).

These fungi produce spores like others, but they may also spread from tree to tree by means of underground hyphae. These are well shown by the HONEY FUNGUS (*Agaricus melleus* L.) or *Armillaria*, in which they are united into bands, rather like thin black shoelaces, termed *rhizomorphs*. The toadstool-like sporophores of this fungus occur in groups at the foot of attacked trees (76).

Root parasites usually kill the attacked tree, but only slowly, and in the meantime they eat out its dormant heartwood from the ground up, causing serious loss of timber. The damaged wood is termed "dotey," "foxy," or "liverish" by the timber man. It is useless and must be rejected. Trees with resinous heartwood resist attack better than others, but only for a time. Unless the infected tree is felled, it usually falls before the wind, for its trunk is weakened at the critical point where it anchors itself to the resistance of the ground. Control measures are difficult, but a change of species may lessen the damage. In many forests it is realised that such conifers as pine and larch can only be grown to a certain age. After that, the occurrence of "heart rot," "red rot," or "butt rot" renders their retention unprofitable.

The principal genus which specialises in root and stem attack is known as *Polyporus*, and includes species also called by some authorities *Fomes* and *Trametes*. These are the Bracket fungi, Polypores, or Dryad's Saddles, conspicuous by their large fructifications which project from the sides of attacked trees. These curious woody bodies have a sloping roof to throw off the rain, and a flat under-surface with multitudinous spore-bearing pores. Some of them endure for several years, growing larger on their outer rim each season. Over thirty species are known to attack forest trees of all kinds. The BIRCH BRACKET (*Polyporus betulinus* Bull.) is one of the commonest and often kills birch trees. RED ROT (*Fomes annosus* Fr.) does serious economic damage to many conifers, Its sporophores are not bracket-shaped, but are irregular in form. They appear most typically on the roots after its victim has been blown down. At that stage these fungi feed saprophytically on the dying tree trunks (74, 77, 79).

Apart from their economic importance, the fungi afford an interesting study to the nature lover. Only in the forest does a wide variety of forms abound, often of attractive appearance and with peculiar names. Thus we have the Blusher, the Panther, the Soldier, Scots Bonnets and Tarragon Oyster, Ivory Caps, Chantarelles, Trumpets, Sweetbreads, Lawyer's Wigs, Fairy's Clubs (71), Judas Ears, and a Wanton toadstool. There is that odd delicacy the Truffle, which never appears above ground but may be scented out of its home in the forest floor by trained dogs or even pigs! Strangest of all is the Parasite (*Nyctalis parasitica* Fr.) which actually grows and feeds upon the toadstool-shaped sporophore of another fungus (*Russula*), a toadstool upon a toadstool!

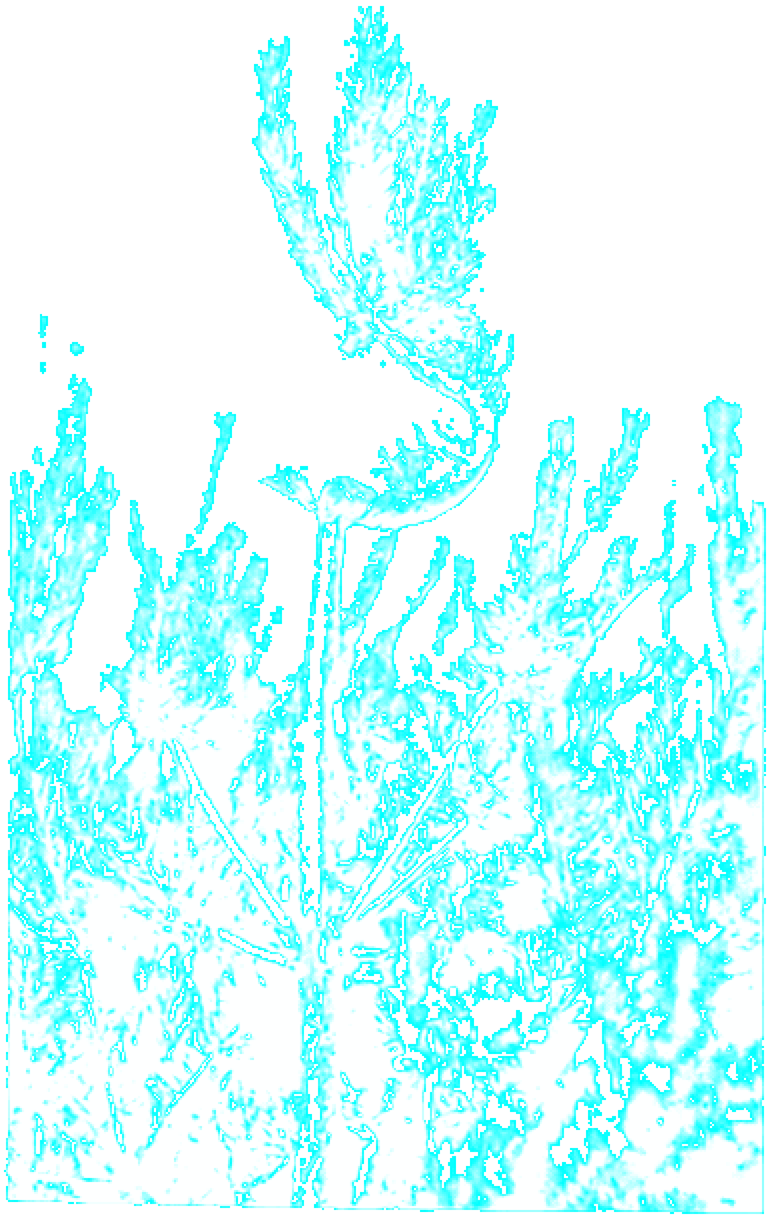
LICHENS

Lichens are curious plant forms compounded of two members, a fungus which forms the main structure and assimilates water and minerals, and a green *alga*, a primitive plant which can synthesise carbohydrates from the air. The lichen is thus self-supporting, and though it needs light it is remarkably independent of the soil. It will grow on bare rocks, but finds the rougher tissues of tree bark equally to its liking. Other forms grow upon infertile soils, and species of the genus *Cladonia* produce flat leaf-like fronds with erect cup-like fruiting bodies on the forest earth. The spores of lichens contain elements of both fungus and alga (66).

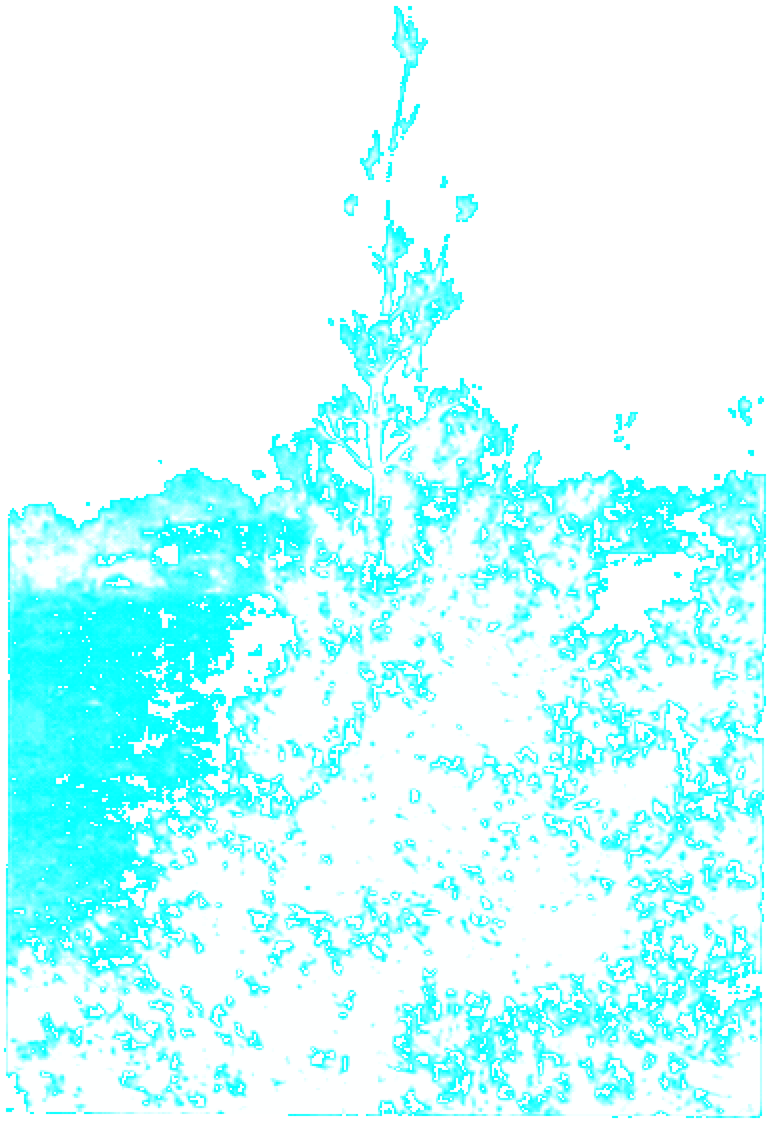
Conspicuous in the woods are the epiphytic lichens, such as the LUNGS OF OAK (*Sticta pulmonacea*), and the BEARD LICHEN (*Usnea barbata* Web.). These have grey, lax, bushy structures, but other species, such as the WALL LICHEN (*Parmelia parietina*) lie like a flat leaf adpressed to the tree's stem. Lichens are usually pale in colour, grey, white, yellow, or brown, the fungal tissues masking the fundamental green of the alga. They do no harm to the tree which supports them, but their presence in undue quantity usually indicates conditions unfavourable to tree growth. A curious feature of the lichens is their sensitivity to impure air. They are rarely found on trees in or near towns, so that they serve as a proof of the absence of atmospheric pollution.

ALGÆ

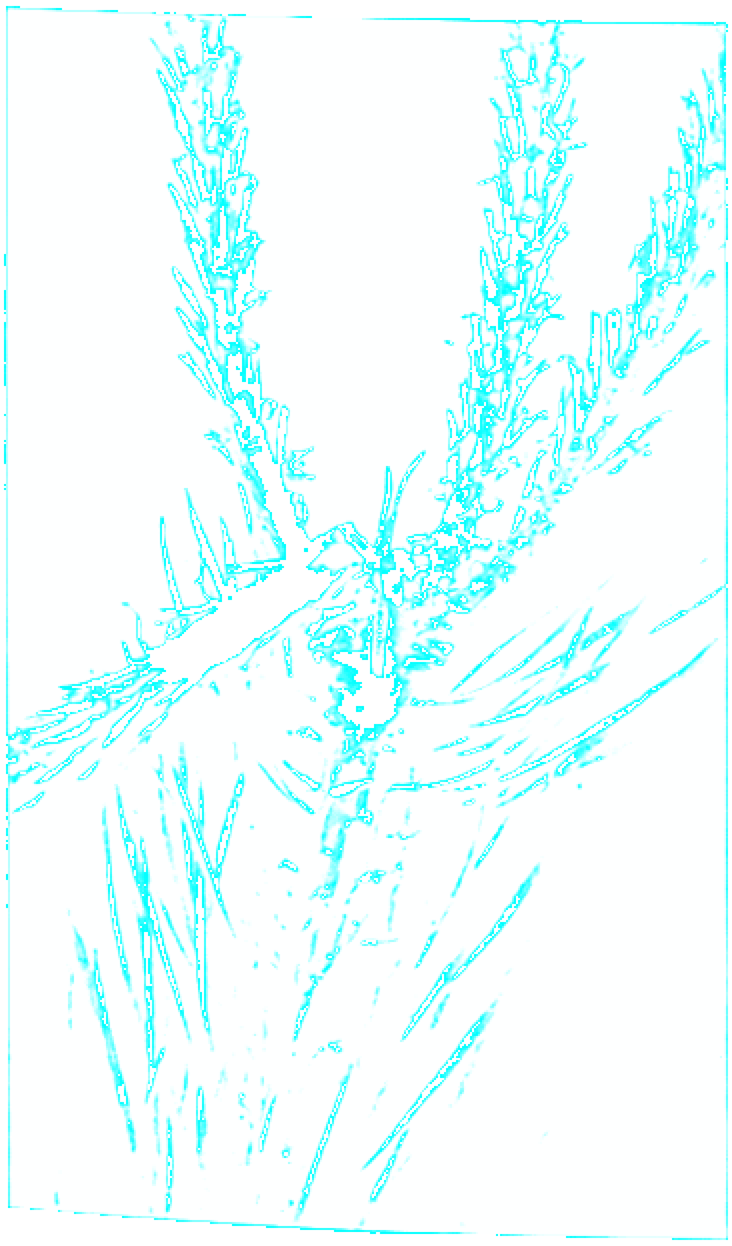
The algæ are primitive green plants composed of cells which are not clearly



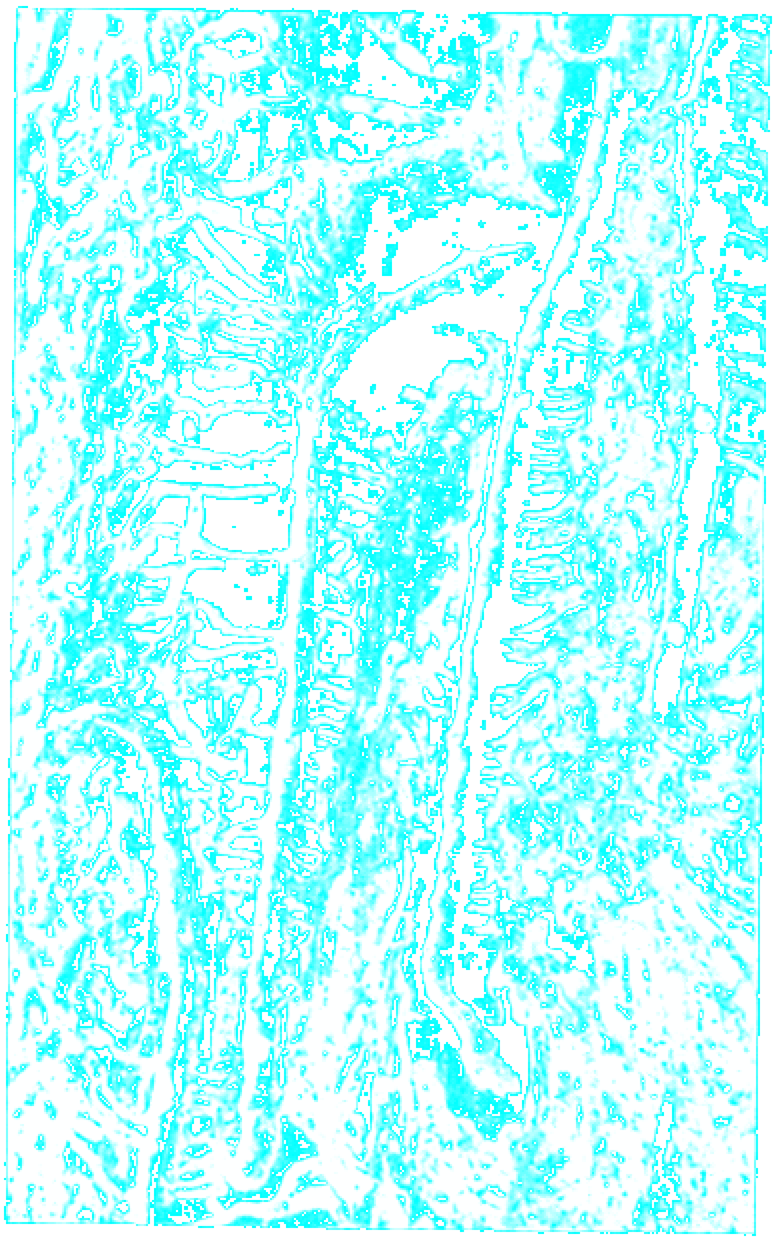
80 SHOOT DISTORTED BY PINE-SHOOT MOTH, *EVETRIA*



81 SHOOT DEFOLIATED BY PINE-BEETLE, *MYELOPHILUS*

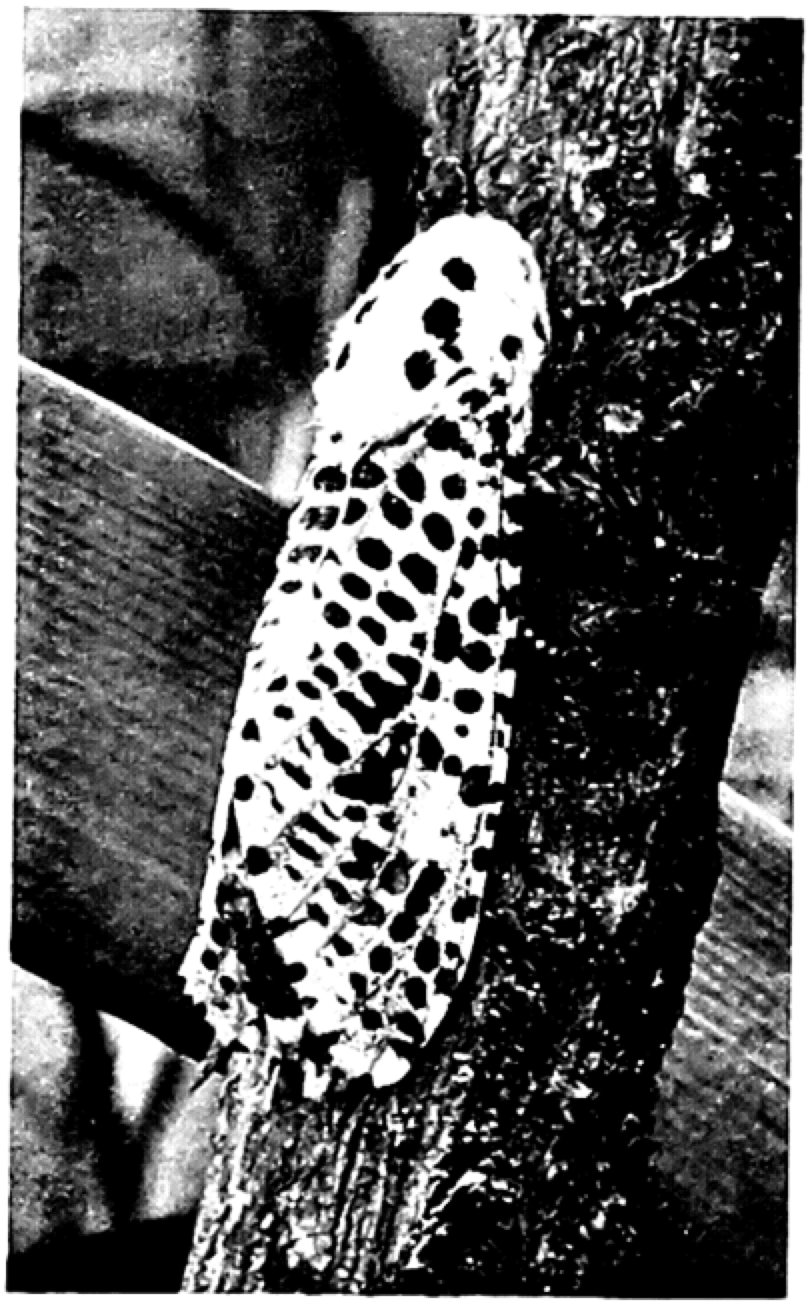


82 THE GRUB THAT DISTORTS THE STEM

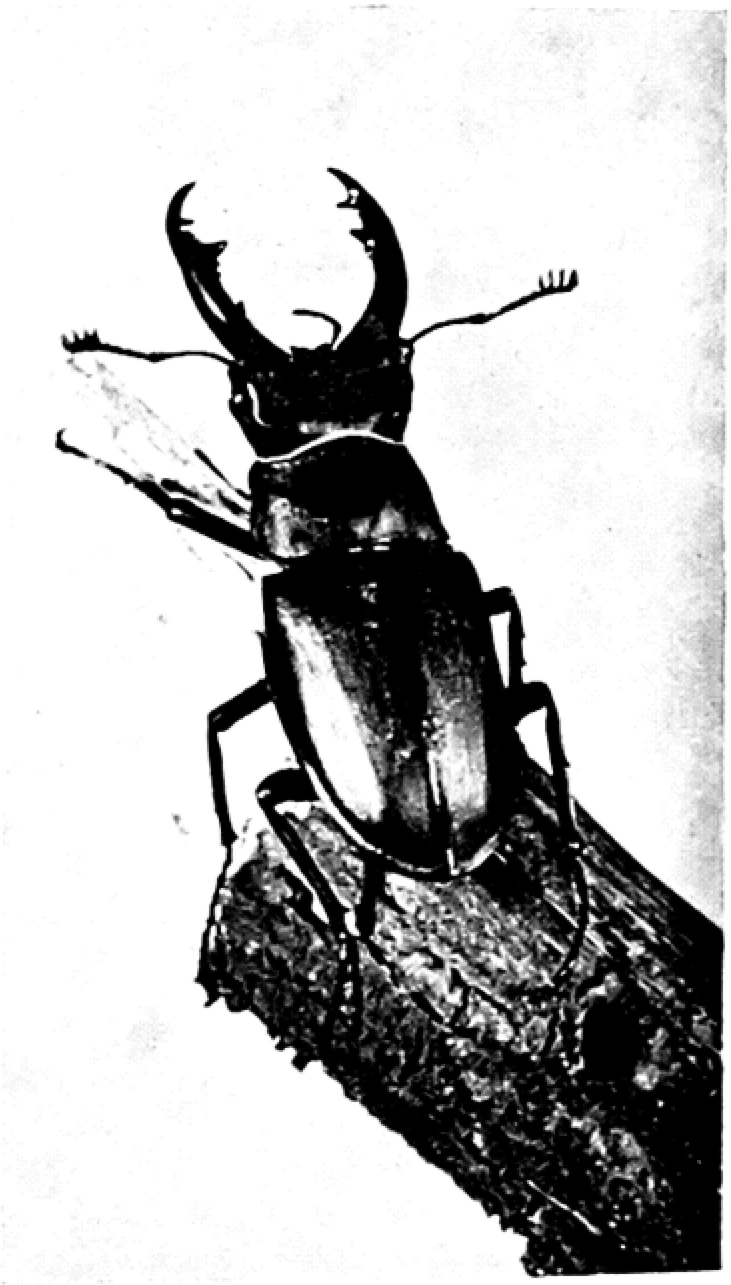


83 BEETLE BREEDING GALLERIES BENEATH A DEAD TREE'S BARK

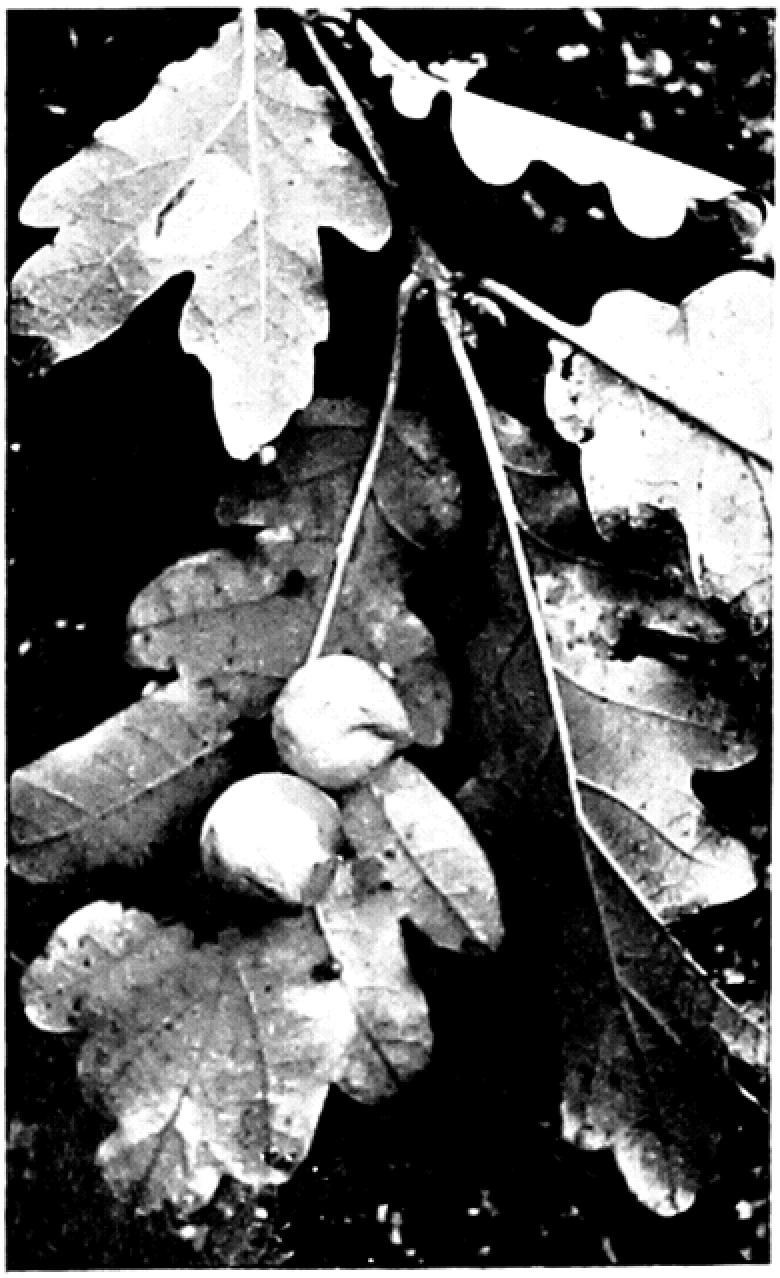
INSECT FOES OF SCOTS PINE



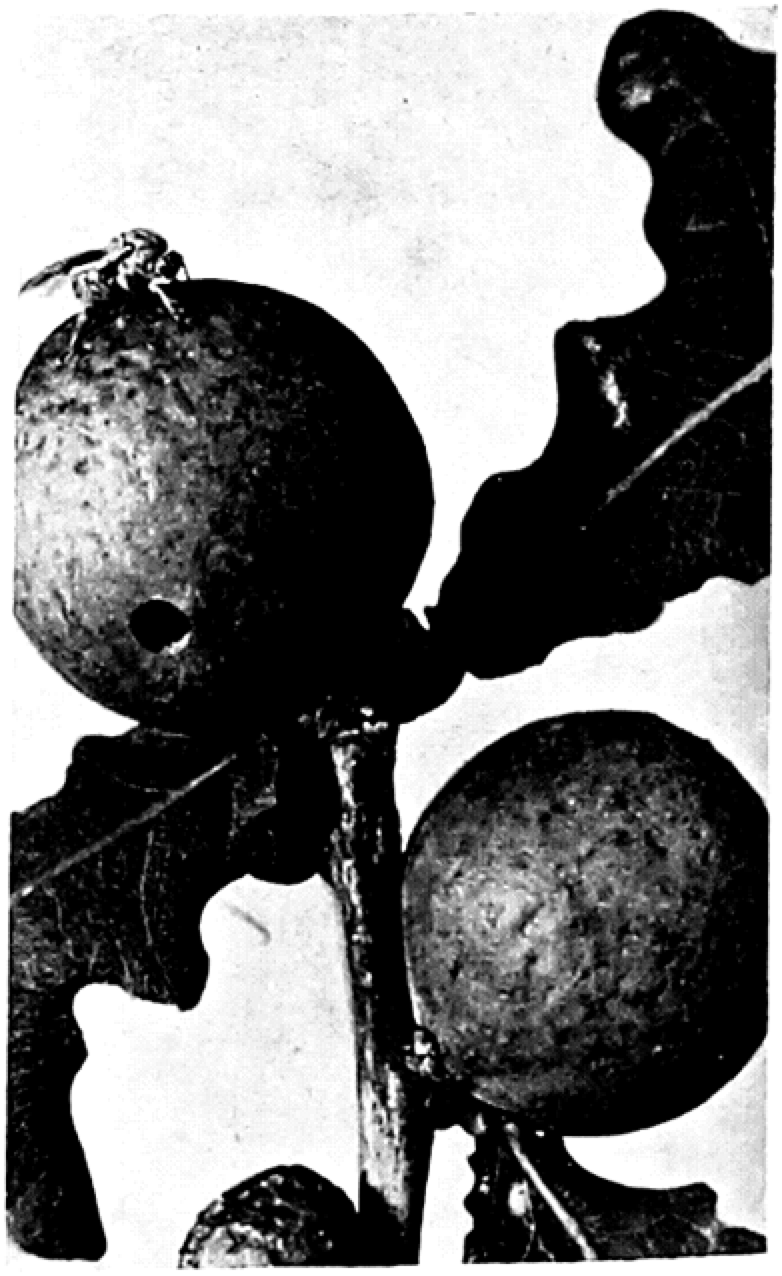
84 WOOD LEOPARD MOTH, *ZEUZERA AESCULI*



85 STAG BEETLE, *LUCANUS CERVUS*



86 OAK LEAF "CHERRY" GALLS OF *DRYOPHANTES SCUTELLARIS*



87 *CYNIPS KOLLARI* ON ITS OAK "MARBLE" GALL

CURIOUS FOREST INSECTS

differentiated into different tissues. Mainly aquatic, they reach their highest development in the seaweeds, but some occur on land under moist conditions. The bark of trees growing in damp woodlands provides them with a suitable substratum, and consequently they frequently grow so thickly as to produce a green coloration on the trunk of the tree, beech being a common subject for their support. *Hormidium* and *Trentepolia* are typical genera. Other forms grow on forest soils.

BACTERIA

On the whole, trees are but little subject to bacterial diseases, though certain *bacilli* such as *Bacillus oleae* are known to cause cankers and tumours on tree stems. But bacteria play an important part in the nutrition of certain trees. Leguminous trees, such as the Locust, contain *Bacillus radicicola* in nodules on their roots, and with its help they are able to utilise the nitrogen of the air. Similar nodules are formed on the roots of the alder by *Schinzia alni*, and are believed to serve the same purpose.

Summing up, a large number of primitive plants benefit by the existence of the forest. Some of these prove dangerous to the trees on which they live and feed, others are neutral, whilst others again assist the tree's growth by various forms of symbiosis.

CHAPTER 9

INSECTS OF THE FOREST

The forest is singularly rich in insects of all kinds. It provides them with a richer food supply, and greater shelter, than any other natural environment. The relationships between the great trees and these tiny animals that teem in their midst are remarkably complex. Many insects feed upon the living tree, others upon its dead timber. Others restore the balance by preying upon these, whilst others assist trees of certain species by carrying pollen from flower to flower. As a rule, the trees not only hold their own against the insect world, but advance despite it. But sometimes circumstances favour some particular pest and, aided by its great powers of multiplication, it may destroy considerable areas of thriving trees.

Insects are invertebrate creatures, with an external bony frame. Their size is limited by their breathing apparatus, which is a simple arrangement of external pores. Their activity is limited by temperature, and throughout the winter months they lie dormant. To make up for these disadvantages, they are gifted with powers of rapid increase, and an immense variability in form, feeding habits, and life histories.

From similar invertebrate creatures, the true insects are distinguished by the division of their bodies into three parts, head, thorax, and abdomen. From the thorax of the adult insect there arise 3 pairs of legs, and 1 or 2 pairs of wings. The adult or *imago* is the fourth and final stage of the typical insect. The first stage is the egg, the second is the wingless *larva* or grub, and the third is a resting stage termed the *pupa*. But by no means all insects pass through these four stages. A typical insect has therefore two resting stages, egg and pupa, wherein it is weak and helpless, and two active stages, larva and imago, wherein it moves about and feeds. An insect may therefore damage trees in the larval or in the adult stage, or in both. The process whereby the insect advances through its four stages, changing greatly in form, is termed its *metamorphosis*.

So numerous are the species of forest insects, that it is only possible to mention a few outstanding representatives of each great group. Fortunately for the forester, the science of Forest Entomology has reached a high pitch of development. The expert is usually able to identify an insect from its larval stage, or even from the damage it does, although the classification of the insect world is based upon the structure of the adult form. As the number of different kinds known to feed on a single common tree, such as the oak, runs into hundreds, this is an achievement in itself. But this intricate science has progressed farther, and it is often possible to ascertain the principal *parasitic* and *predatory* insects which attack the mischief-maker. Such parasites may then be introduced from other localities to help combat the damage.

LEAF-EATING LARVÆ

The leaves of a tree are the organs most generally susceptible to insect attack. This may be likened to the damage done in the garden by allied caterpillars;

and as might be expected, the larvæ that feed on tree leaves are chiefly those of butterflies and moths. Taken together, these two types of insects comprise the natural order of the *Lepidoptera*, distinguished by the scaly coverings of their four wings in the adult stage. Hundreds of butterflies and moths inhabit the forest, each with its favourite host plant. Those which do most damage are often the most insignificant in appearance.

THE GREEN OAK ROLLER MOTH (*Tortrix viridana* Linn.) is only about three-quarters of an inch from wing-tip to wing-tip, with green fore-wings and grey hind-wings. Its larvæ feed on oak leaves, which they roll up in order to protect themselves. They feed in June, then pupate, emerge, and pair; the winter is passed in the egg stage. In favourable seasons the larvæ emerge from the eggs, which are laid on the twigs of old oaks, in enormous numbers. Commencing to feed all at the same time, they may strip whole trees or woods bare of young leaves. Thus, in June, 1933, thousands of acres of old oak woods in the Gloucestershire Forest of Dean were stripped of every green leaf. They looked like the gaunt skeletons of winter. Yet the attack was not fatal. When the grubs pupated, the oaks sent forth their " Lammas " shoots, and by the end of July the forest grew green again. But such an attack strains the reserves of any tree, even an oak, and checks growth and timber production.

Similar damage is done to pine plantations by the PINE SAWFLY (*Lophyrus pini* Linn.), a *Hymenopterous* insect with two pairs of translucent wings united together. Its caterpillars live in groups, feeding on pine needles. As two broods or generations are produced each year, its spread is rapid in young plantations until these grow tall enough to shelter its bird enemies. It checks growth severely.

LEAF-SUCKING BUGS

Despite their small size, insects of the order *Hemiptera*, in which both winged and wingless generations occur, are familiar to gardeners in the form of *Aphids* or Greenflies. Certain aphids attack forest trees, but the most important, economically, of this group are the Plant-bugs of the genus *Adelges*, also known as *Chermes*.

These may be seen as tiny specks, clothed in sticky white down, on the needles of many conifers. Their life-histories are complex, and quite different to those of ordinary insects. Frequently they feed in different ways at different stages, attacking different trees. A very curious feature is their *parthenogenesis*. For several generations, the females produce young without pairing. At length a generation which contains both sexes appears, these pair and the cycle recommences.

THE DOUGLAS FIR ADELGES (*Adelges cooleyi* Gillette) is interesting as being a foreign insect that has made its home in Britain, having been imported accidentally from western North America. Both its host trees, Sitka spruce and Douglas fir, come from that region, but both thrive so well in Britain that this common pest does little significant damage to either. It has a typically complex life cycle.

Each spring an egg, laid on the Douglas fir, hatches out into a female bug called a " stem mother," which develops from the larval stage to the adult without any clearly-marked pupal period. She then produces a generation of females parthenogenetically, without pairing. These in turn produce others, all being wingless, minute insects, which suck the sap from the needles of the Douglas fir by means of specially modified mouth parts.

Finally, winged females appear, which fly to the Sitka spruce, and produce a new generation of two sexes. After pairing, these produce wingless females which live on spruce needles, causing curious galls like little pineapples. This form of damage is so different in appearance to that found on the Douglas fir, that at first sight it may be taken for the work of an entirely distinct insect. Eventually, there arises another generation of winged females, which carry the life-cycle back to the Douglas fir, and lay thereon the eggs which give rise to the " stem mother " of the following spring.

These minute insects do damage by virtue of their rapid rate of increase in a single season. Fortunately they have many enemies, and are only dangerous pests on trees grown out of their true habitat. As an example of their serious effect in such instances, one may cite the SILVER FIR ADELGES (*Adelges nusslini* Börner) which feeds on the European Silver fir. It attacks both leaves and young stems, causing die-back when this tree is grown in unsuitable surroundings. In central Europe, it is only of minor importance, but in Britain it has proved so serious that the European Silver fir is no longer used here for commercial afforestation, allied species from North America being planted instead.

BARK BEETLES

We have seen that the leaves, the most vulnerable portion of the tree, are attacked particularly by the biting larvæ of moths, butterflies and sawflies; and also by both larval and adult stages of the sap-sucking plant bugs. Another group of insects specialises in attacks upon the soft bark and bast tissues, and also the sapwood of trees either in a living or a dead state. These are the *Coleoptera* or Beetles, distinguished from other insects by their hard horny wing cases, which protect a single pair of wings. Most of them have strong biting mouth parts in both their larval and adult stages, and so are well equipped to eat their way through tough woody tissues. Both these stages feed actively, and it is sometimes the larva, sometimes the adult, that does serious harm to the forest trees.

It is these beetles which produce the curious designs often found below the bark of felled trees. The adults of certain species bore their way in from outside and pair in a " bridal chamber " which they excavate just below the bark. Then the female bores out a long gallery, laying eggs at intervals along it. As each egg hatches, the grub strikes off its own tunnel at right angles to the mother's gallery. It eats its own passage, avoiding the burrows of its brothers and sisters. At the end of this it pupates, and the adult insect which results emerges through a small hole which it bites through the protecting bark. When the bark is removed, the whole " family history " is revealed to the observer (83).

The most important of the Bark beetles is the PINE WEEVIL (*Hylobius abietis* Linn.), a black and yellow beetle about half an inch long, with the long snout which distinguishes the Weevil group of beetles. It lays its eggs in the stumps of *dead* pines, and its larva, a plump, white grub, feeds on the decaying bast tissues below ground. Harmless enough, one would think, and so, at that stage, it is. Nor does the adult insect, which feeds on the soft bark and bast of young conifer shoots, do much serious damage in natural woodlands. But in cultivated plantations man sometimes upsets the balance of nature, and favours the spread of this little weevil to such an extent that it is ranked as the worst of the insect pests of our forests.

The felling of large areas of pinewoods provides an ideal breeding and feeding ground for the larvæ, since an abundance of dead pine stumps is provided for them. When, a year or two later, the cleared ground is replanted, either with pine or with any other coniferous tree, the adults, emerging in large numbers, have nothing on which to feed except the young conifers, which have been raised and planted at considerable cost, and are weakened by their recent transplantation. They swarm upon these, nibbling their bark and bast until their main shoots are cut completely round, and as like as not, wipe them out, making the planting a total loss. For this reason the re-planting of former pine plantations is commonly postponed for two years in the south of England, and for three or four years further north, where the attack takes longer to reach its climax. After this period, the peak of the epidemic passes. No more fresh stumps remain for the larvæ to feed upon, and they are gradually crowded out of the existing old stumps by their own feeding and that of other beetle larvæ. Also, their natural enemies are increasing proportionately, and finally gain the upper hand. So the areas slowly become safe for re-planting.

The Pine weevil is a sluggish creature, and may be controlled to some extent by " traps." These consist of billets of unbarked pine stems, buried in shallow trenches together with sprays of pine foliage, at intervals throughout the planting areas. The adults come to these to feed on the foliage, and to lay their eggs in the billets, and may be collected by hand and destroyed.

This weevil must not be confused with the PINE BEETLE (*Myelophilus piniperda* Linn.), an active, blunt-headed little creature, black in colour, and only one sixth of an inch long. It lays eggs in the bark of newly felled pine logs, producing the usual layout of breeding and feeding galleries which typifies the Bark beetles. After a few months growth, the larvæ pupate and then emerge through numerous little exit holes, which look like shot holes in the bark. After flying to the tops of pine trees, the adult insects bore into and severely damage young side shoots. This checks the growth of the attacked pines, since their lateral branches are suppressed for at least a season's growth. The leading shoot continues its upward growth, resulting in a narrow, spire-like crown, whilst the summits of the trees present a woe-begone and tattered appearance for some years after the attack. Young trees suffer most (81, 83).

Control of this pest is simple. If all timber is removed from the forest, or barked, within two months of felling, the life cycle is broken. The adults, if they emerge at all, do so where they can achieve no damage. This precaution is less necessary in winter, as the Pine beetle only breeds in the summer months.

Some bark beetles do damage in another way, by carrying the spores of harmful fungi from one tree to another. For example, a small beetle whose larvæ feed upon the elm, *Scolytus multistriatus* Ratz., carries the infection of the deadly fungus causing the DUTCH ELM DISEASE, *Ceratostomella ulmi* Buisman.

WOOD BORING BEETLES

Distinct from the bark beetles which feed on soft bast or bark tissues, the wood-borers are designed to live in, and feed on, the underlying sapwood. As a rule they do not harm living trees, but prefer to lay their eggs on dead timber. Their larvæ burrow deep into the wood, leaving tunnels filled with excrement and damaged wood termed *frass* (German: *fressen*, to gnaw). The best known is the DEATH WATCH BEETLE (*Xestobium rufo-villosum* De Geer), so called from the tapping noise made by the adults calling to one another, which was held by superstitious people to presage a death. This is a little brown beetle, only a quarter of an inch long. In the forest, where it feeds on decaying oakwood, it is of no great importance. But where it occurs in the timbers of old houses and similar buildings, its tiny larvæ can work enormous damage. Their round tunnels, and the rotten condition of the wood, reveal their presence and may weaken great beams until whole buildings collapse. Warmth and damp favour their spread. Other species, such as the Anobiid beetles, favour furniture, but most can be checked by chemical treatment.

GALL WASPS

" Oak Apples," " Marble Galls," and " Spangles," curious swellings on the stems and leaves of oaks, are the work of gall-forming insects, chiefly members of the order *Hymenoptera.* These are wasp-like insects with two united pairs of transparent wings. The hard, round, brown Marble galls are produced by *Cynips kollari* Hartig. This tiny wasp has a most complex life history, and at another stage produces quite a different and inconspicuous type of gall forming a thickening of the tissues of oak leaves. The number of species of gall-formers runs into hundreds on the oak alone. Besides the true gall-formers, which cause the tree to produce the curious swellings in which they hide, other tiny insects live in the galls, feeding on the abnormal tissues which they cannot themselves produce. And still others live parasitically upon both types of vegetarians. Tree galls furnish an interesting study, but fortunately none causes really serious damage to any of our timber trees (86, 87).

ROOT EATING INSECTS

Even the roots of trees are not immune from insect attack. The large fat larvæ of the COCKCHAFER BEETLE (*Melolontha melolontha* Linn.) causes serious damage in nurseries by destroying the roots of seedlings. The large, brown, winged beetles are active creatures which feed on the leaves of broadleaved trees, but it is the " White Grubs " which cause the effective mischief, by attacking both broadleaved and coniferous seedbeds indiscriminately. They live for two or three seasons in the soil, feeding in summer near the surface, and retiring to deeper levels in winter. The control of such an underground pest is difficult, especially as the forest trees cannot be lifted in the summer when the grubs are within reach. Infested ground must therefore be cropped with some succulent plant, such as early potatoes, which can be dug up during summer. In the process, large numbers of the grubs can be collected by hand and destroyed.

SEED EATERS

Some insect larvæ are so small that they gain enough nourishment for their needs from seeds, even those of conifers. *Megastigmus spermotrophus* Wachtl., a tiny wasp, frequently eats out the seed of Douglas fir, whilst allied species attack spruce seed, working right through a cone, destroying the seeds in succession. Not only do they feed on seeds in the forest, but they may also do damage in seed stores.

STEM BORERS

THE PINE SHOOT MOTH (*Evetria buoliana* Schiff.) lays its eggs on young growing shoots of pines. Its larvæ burrow into these, feed on the soft tissues and weaken the stem until it bends or breaks. A distorted tree often results; sometimes the leading shoot ceases to grow and a side-shoot takes its place, causing a bend; at other times the leader resumes its upward trend after being twisted out of line (80, 82).

PARASITES AND PREDATORS

The " Rogues Gallery " of harmful forest insects listed above is only a small selection of the criminals which attack growing trees or useful timber. So numerous are they, that were it not for the activities of other insects, not a tree could survive. But, as is aptly expressed in the old rhyme,

> " The bigger bugs have smaller bugs
> Upon their backs to bite 'em.
> Those little bugs still lesser bugs,
> And so *ad infinitum.*"

Carnivorous insects conspire, or rather compete, with insect-eating birds and other animals to keep the vegetarian insect population of the forest within reasonable bounds.

The *Predators* are the active hunters, such as LADYBIRD BEETLES (*Coccinellids*) both the larvæ and adults of which attack leaf-sucking bugs, devouring many in succession. The *Parasites* have a more sinister and rather grisly mode of attack. Each insect, usually in the larval stage, destroys a single grub of its host species, by devouring its body from within. Usually one larva feeds upon another, and the victim is in many cases paralysed by the parasite so that it is not only helpless but probably also insensitive to its slow destruction.

Typical of these is the ICHNEUMONID wasp which attacks the Pine weevil (*Hylobius*). Its scientific name is *Ephialtes tuberculatus* Geoffr., and it is a large, rather handsome insect which may sometimes be observed in summer winging its way through the pinewoods. The female has long antennæ, with which she sounds the surface of pine stumps to detect the larva of the Pine Weevil at work below the thick bark. Having detected an unfortunate grub, she thrusts her scimitar-like ovipositor, or egg-tube, through the bark into the body of the victim which she cannot see. An egg is laid, and after it hatches her larva begins its insidious work of eating out the body of its host. So that instead of an adult weevil, an adult Ichneumonid ultimately emerges.

Clearly, the study of these carnivorous insects is of great economic importance. Wherever they can be introduced or encouraged they prove invaluable allies in the control of harmful forest pests.

OTHER FOREST INSECTS

Besides those of economic importance there are many other interesting insects found in the forest, but not elsewhere. Conspicuous are the WOOD WASP (*Sirex gigas* Linn.), brightly banded like a great hornet, and its steel-blue cousin *S. cyaneus. L.* Two inches long, they whirr through the woods to lay eggs in dead or decaying softwoods with the help of saw-toothed ovipositors. Their larvæ excavate large tunnels in unsound timber.

THE STAG BEETLE (*Lucanus cervus* Linn.) is a great black brute, the male being three inches long. The species is named from the antler-like structures which he bears on his head. A harmless creature, though of terrifying appearance, this insect feeds on decaying oak wood (85).

The woodland is the true home of the Ants, who pasture their Aphids on certain forest trees, even the pine being sometimes affected. Also of the Hornets, who construct their papery nests with materials derived from tree bark. Dragonflies haunt the forest streams, and many rare species of butterflies and moths are encountered only in the woodlands. Nearly all the great natural orders of insects have their woodland representatives, so that the woods form an important hunting ground for the entomologist.

Amongst the more conspicuous and beautiful of the woodland butterflies, there may be mentioned the Brimstone, which feeds on Alder buckthorn, the Purple Emperor and Camberwell Beauty, feeding on willows, the Wood Leopard moth (84), and the White Admiral, whose caterpillars prefer the leaves of the honeysuckle.

There is also a vast unseen insect population in the leaf mould of the forest floor, where myriads of animalcules draw their sustenance, directly or indirectly, from decaying leaves and branchwood. Along with the fungi and bacteria, they help to break these down into substances from which tree roots can obtain nourishment; and in this way they are believed to play an essential part in maintaining the fertility of the forest soil. Individually they are minute, but they occur in such numbers that their combined effect may be of great importance.

THE CONTROL OF INSECTS

In the garden and on the farm or orchard, insects may be controlled by sprays or poisons. But in the forest such methods are seldom effective. The areas of ground and leaf surface are too great, and the dose must be applied from an aeroplane and repeated season after season in order to safeguard a single timber crop. Of more practical value are the careful selection, planting and tending of tree species well adapted to the locality, so that the trees do not fall into the weakened state in which insect attack becomes dangerous. In some cases, as with the Pine beetle, it is possible to regulate the environment so as to render it unfavourable to the insect's course of life; that is, by such measures as removing the fallen or felled logs in which the insect breeds.

Carnivorous insects may be introduced or encouraged, and exceptionally human hunters may be employed, as for the Pine weevil and the cockchafer. But perhaps the greatest aid is given by useful forest birds. The outbreak of the Oak Roller moth in the Forest of Dean, mentioned above, occurred in an area singularly poor in bird life, owing to the woods being open to grazing sheep which disturbed the nesting birds and also checked the undergrowth which they love to haunt. Wherever birds are protected, such epidemics are rare. The study of forest bird life is therefore important for the effective control of the insects.

Insects are only one of many groups of invertebrate animal life. Spiders, woodlice, and earthworms, are other examples of the more minute fauna of the woodland world. But although these teem in the forests, their influence and importance have so far been but little explored.

CHAPTER 10

WOODLAND BIRDS

Woodland is the natural home of the perching birds which are frequently associated with field and garden. Before the work of farmer and gardener in modifying the natural countryside became so widespread, such common birds as chaffinch and thrush were mainly to be found in wooded country. There they still persist, along with a variety of other shyer, rarer birds, which have never left their native trees to adapt themselves to a man-made environment.

There are, of course, a great number of sea and water birds, and frequenters of moors and mud-flats, which are not at home in wooded country. But even amongst these there are a few, such as the heron, which resort to the woods in order to nest in tall trees. Certain birds, moreover, are adaptable in their habits of feeding and nesting. As was first recorded by the ornithologist Temminck, species which nest on cliffs or at ground level in open country, will readily resort to trees when they settle in or near woodland.

Not only do the woods harbour rare and interesting birds, who benefit by the abundant food, shelter, and nesting sites found therein, but the birds are essential to the life of the trees. They attack insects at every stage of their life history, consuming prodigious numbers. A single pair of nesting warblers will bring grubs to their nest at the rate of one per minute, which means five or six hundred destroyed in the course of a single long summer's day.

Unlike the carnivorous insects, which specialise on one particular class of insect food, the birds attack a great variety of eggs, larvae, pupae, and adult insects. Of course they devour the useful insects along with the harmful ones. But as the latter are far more numerous, and usually less active, the general effect is beneficial. Birds range much farther than do preying insects, and so can concentrate from a distance upon any outbreak of a forest pest. Furthermore, all birds are warm-blooded creatures, and none of them hibernate; many of the insect-eaters desert our shores on the approach of winter to seek warmer climes, but others from farther north migrate inwards to replace them, and there is a useful body of resident birds that attack insect life the whole year round. In contrast to the carnivorous insects, which feed only in the warmer seasons, the birds *must* eat the whole year round. In winter they often concentrate their feeding on the resting stages of insect life, eggs and pupae, thereby greatly reducing the size of the next summer's insect population.

Most woodland birds are insectivorous during their breeding season, when they have nestlings to feed. This spring insect catching goes far to check the upward surge of the insect population of the woods, which occurs at that season. At other times of the year, many of them prefer to feed on seeds and fruits, which are so plentiful in the forest that their loss is seldom felt. Therefore the forester may regard almost every bird as an ally in promoting the growth of trees.

GAME BIRDS

Foremost amongst the British woodland birds is the PHEASANT (*Phasianus colchicus* Linn.). Some ornithologists pay scant attention to this handsome, long-tailed, friendly bird, on the grounds that it is introduced and protected by man. But it has been with us for hundreds of years, probably since Roman times, having been introduced from Asia Minor. Another form, the Ring-necked pheasant, is a later importation from China, and the two interbreed. In " rough-shooting " country, where it is not closely protected, the pheasant tends to be monogamous, pairs of a cock and a hen keeping together throughout the year. But on sporting estates it is customary to shoot the cock birds and spare the hens, to keep up numbers, and there the cock pheasant becomes polygamous. Though it has many foes, the wild pheasant is well able to look after itself, without the intensive protection which its semi-domesticated cousins receive from the gamekeeper. It eats quantities of seeds and fruits such as acorns, but as it also devours quantities of ground-feeding grubs and insects, its work in the woodlands is mainly beneficial.

The pheasant plays an important part in rural economy. It is more than likely that many old woodlands would have disappeared, but for their value as pheasant coverts. In mixed woodland of several tree species of various ages, pheasants maintain their numbers well. With careful management both the sporting and timber value of such plantations can be maintained together. In many cases the woods greatly enhance the sporting value of the estate as a whole.

The GOLDEN PHEASANT, a smaller, more brightly coloured bird, is now naturalised in the woods of Wigtownshire, Norfolk, and Hampshire.

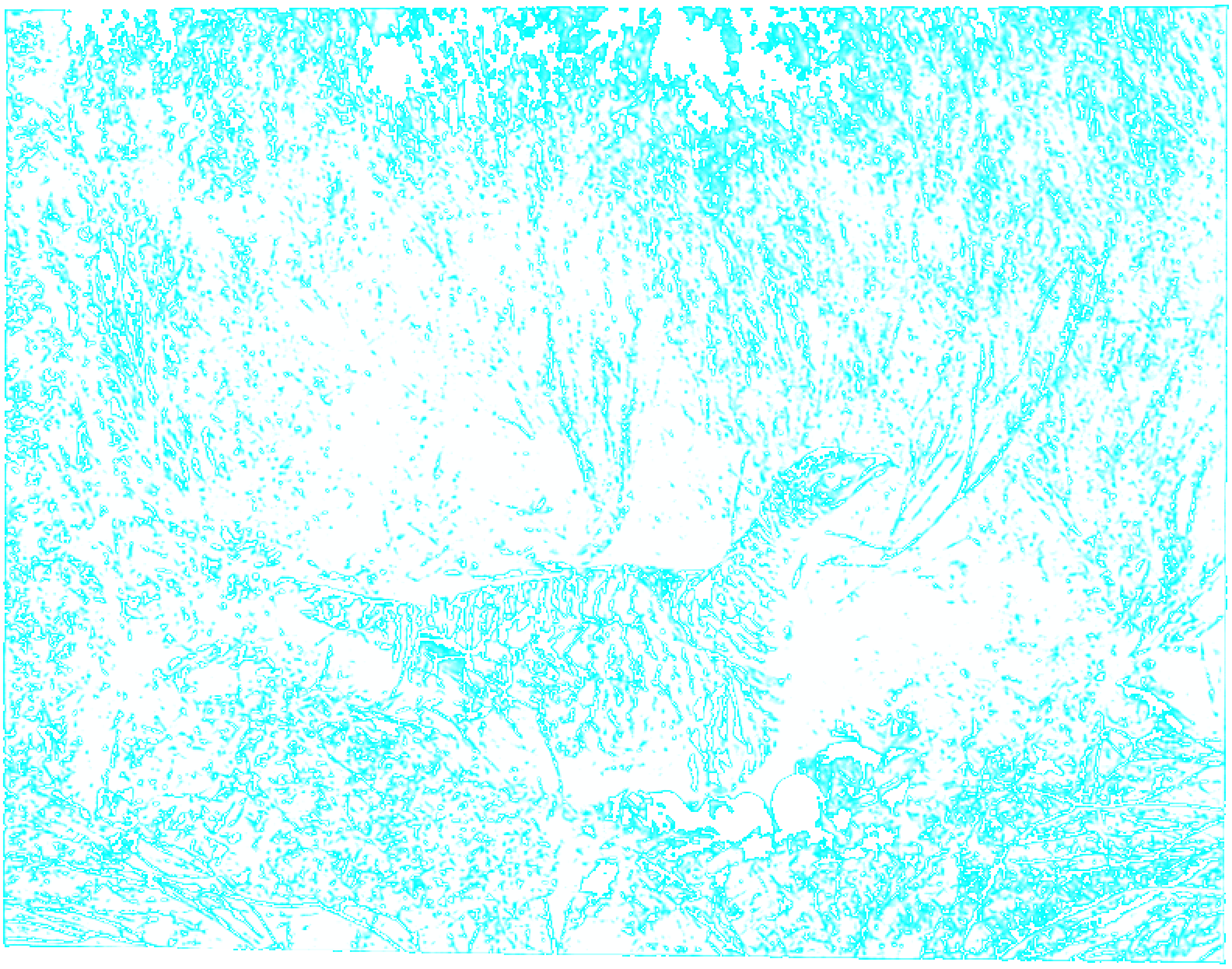
The CAPERCAILLIE (*Tetrao urogallus* L.) (88) or Cock of the Woods, is a less familiar bird found mainly in the Scottish Highlands. One of our largest birds, the male is black in colour and three feet in length. The female, brown, measures only two feet. They resemble turkeys in build, and fly noisily through the woods, making a commotion like an express train. Exterminated in the eighteenth century, the capercailzie was reintroduced in 1837 and is now protected. It is polygamous. Its name has a curious derivation from the Gaelic *Capal-coille*, meaning " horse of the woods."

The allied BLACK GROUSE (*Lyrurus tetrix* L.) is, alas, almost if not quite extinct in southern England, but survives in Scotland. The male " Black Cock " is much handsomer than the female " Grey Hen." They are remarkable for their communal courting displays in the breeding season.

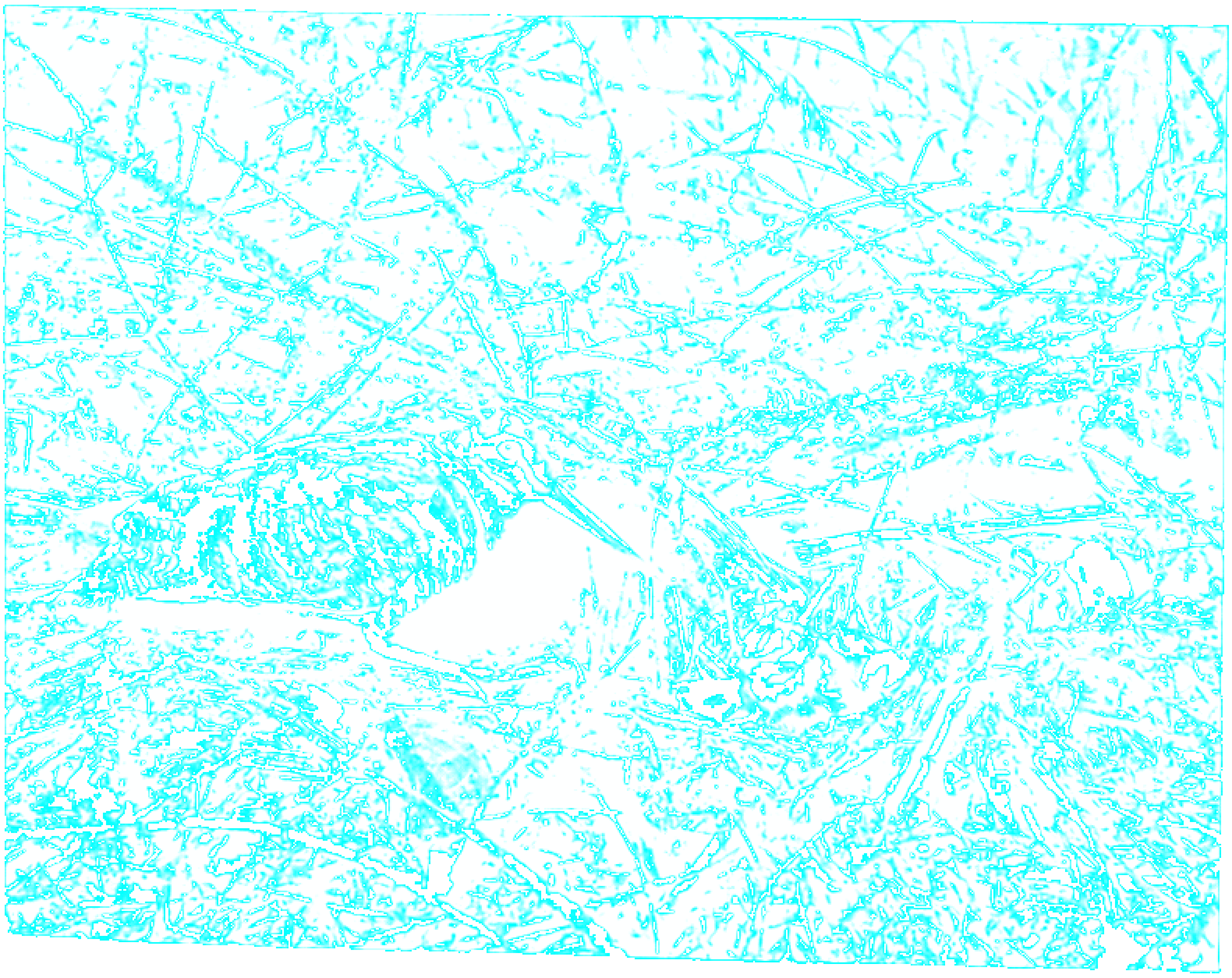
Both these birds are haunters of the forest, preferring birch and pine woods. They feed largely on insects, but have an unfortunate habit of eating the tender young shoots of pines and other conifers. For this reason they are black-listed by many foresters, yet it is possible that they do a certain amount of good by devouring insects such as Pine weevil and Pine sawfly. In moderate numbers, and where there is a proportion of older plantations, they may be tolerated. They are well established in the Perthshire Highlands, amidst some of Scotland's finest forests.

The RED GROUSE (*Lagopus scoticus* Latham) is a moorland bird, but occasionally feeds on the fringes of upland plantations in Scotland and the north of England.

Another game bird of the woods is the WOODCOCK (*Scolopax rusticola* L.) (89) a snipe-like brown bird which probes the ground for insects, such as cockchafer



88 CAPERCAILLIE HEN BROODING NEWLY-HATCHED CHICKS



89 WOODCOCK RETURNING TO ITS CHICKS

GROUND-NESTING GAME BIRDS

90 REDSTART

91 CRESTED TIT

92 CROSSBILL

93 GREAT SPOTTED WOODPECKER

grubs, with its long bill. A useful bird, it nests on the ground, and the hen has the curious habit, when disturbed, of picking up her young and flying away with them. The writer was once privileged to observe this interesting performance in the woods near Alderley Edge, Cheshire; but on that occasion the tiny passengers were dropped shortly after the " take-off."

PIGEONS

Three species of pigeons haunt our woods, feeding mainly on seeds, especially acorns. They nest in tall trees, laying two white eggs on a rough platform of sticks. Although they do no great damage to tree crops, they raid the farmer's fields and therefore require keeping in check. The Ring dove (*Columba palumbus* L.) (94) is commoner than the Stock dove (*C. oenas* L.) which lacks the white neckband of the former species. Both are rosy blue-grey in general colour, and wary birds of erratic flight. The prettily-marked grey Turtle dove (*Streptopelia turtur* L.), somewhat smaller, is a summer visitor to the southern English counties. The other two species are residents.

CROWS

The crow tribe is well represented in the woodlands. All its members are omnivorous, but live largely on insects. The raven (*Corvus corax* L.) and the Carrion crow (*Corvus corone* L.) are usually encountered in pairs, but the similar black rook (*C. frugilegus* L.) moves about in flocks, and nests in the familiar treetop colonies termed " rookeries." With it is often found the smaller, more graceful jackdaw (*C. monedula* L.), which is equally at home amongst trees as upon cliffs or buildings.

The picturesque long-tailed black-and-white magpie (*Pica pica* L.) is usually found in or near woodland, especially in the north. Further south is found the beautiful jay (*Garrulus glandarius* L.), a large, slender, rosy-brown bird with black, white, and brilliant blue markings, familiar for the chattering cry with which it greets intruders. The gamekeeper has little to say for any of the crows, for they are addicted to stealing game-birds eggs. But as they undoubtedly consume harmful insects all through the year, the forester will not begrudge them an occasional omelette during the spring season.

THE STARLING (*Sturnus vulgaris* L.) can damage trees in a curious way. It roosts in flocks so vast that their droppings poison the ground beneath the chosen roosting tree, and quite large trees may be killed in this way. This damage is very local, and on the whole the starling is useful as an insect eater.

THRUSHES

So familiar are the thrushes in our gardens, that one is apt to forget that their true home is the woodland. They remain with us throughout the year, and are almost entirely insectivorous, occasionally resorting to fruit or berries. The yellow-billed blackbird (*Turdus merula* L.) with his brown-hued mate, is perhaps the most handsome. The Missel thrush (*T. viscivorus* L.), a brown bird with a spotted white breast, favours tall woodlands. His beautiful, clear song, trilled from the tree-tops amidst the worst spring weather, has earned him the name of " Storm Cock." He is larger than the commoner sweet-voiced Song thrush (*T. ericetorum* Turt.), who haunts the undergrowth. Their allies the redwing and the fieldfare are winter visitors who search such trees as the yew, holly, and hawthorn, for their rich red berries. The berry crop helps the thrushes to survive the winter so that they may continue insect eating in the spring. So do the trees assist their bird guardians, who also distribute their seeds.

THE ROBIN (*Erithacus rubecula* L.) or redbreast, is as tame in the woods as in the garden. In winter he follows the wood-cutters, knowing that the felling of the trees will disturb tiny insects hibernating in crevices in their bark.

THE REDSTART (*Phoenicurus phoenicurus* L.) (90), a bird of similar size and build, distinguished by its bright plumage of white, black, red, and chestnut brown, is a summer migrant who does useful work as an insect eater. He prefers to nest among streamsides. The name signifies " red tail," the word " start " being still used in that sense in country dialects.

THE NIGHTINGALE (*Daulias luscinia* L.) (5) nests in thickets on the woodland fringes in the southern counties, enchanting the ear at dusk with his love-song. A summer visitor, this delicately-built brown songster is an active insect eater throughout his short sojourn with us.

WARBLERS

The thrushes and robins do useful work throughout the year, but their numbers are insufficient to cope with the enormous increase of insect life that ensues with the warmth of summer. This attracts to our shores the delicate, sweet-voiced warblers, who winter in the tropics and the southern hemisphere. The largest and prettiest is the Wood warbler (*Phylloscopus sibilatrix* Bechstein), which trills its joyous little song from the tree-tops. Five inches long, it is yellowish green above, white below, and is also known as the Wood Wren. The brown Grasshopper warbler (*Locustella naevia* Boddaert) has a song like the chirruping of a grasshopper. Others of this group are the whitethroat, the blackcap, the Garden warbler (who prefers woods to gardens), the chiffchaff, and the Willow warbler or Willow Wren. Each has its distinctive markings, song and nesting habits.

Allied to these is the GOLDCREST (*Regulus regulus* L.) our smallest bird, which remains throughout the year as a haunter of coniferous woods. Built like a wren, it is green in colour with a bright orange crest, and measures only three and a half inches long. It feeds on tiny insects, and as it is often these more minute creatures that do most serious harm to forest trees, the Goldcrest's good work is out of all proportion to its size. It builds a beautiful, intricate, cup-shaped nest of moss, pine needles, wool and cobwebs, placed as a rule on the branches of some coniferous tree.

Another warbler-like bird is the DUNNOCK (*Accentor modularis* L.) also known as Hedge Sparrow. Resident throughout the year, this slender bird is frequently found haunting the undergrowth, seeking for insect food. It is dull brown above, slate-grey below, unobtrusive and inconspicuous, and rather bold in the presence of man.

FINCHES

The finches, buntings, sparrows and their allies are equipped with stout, hard, bills adapted for seed eating. But in spring, when they have young families to raise, they prefer an insect diet. Even the House sparrow has been recorded as requiring 90% insect food at that period, whilst the chaffinch, linnet, and yellow hammer become out-and-out insect eaters.

Commonest of the finches, in the woodland as elsewhere, is the chaffinch

(*Fringilla coelebs* L.), believed to be the most numerous species of British bird. Brightly feathered in warm brown and blue, with black and white markings, he haunts the copses with his clear call of "Pink! Pink!" Along with the greenfinch and the bullfinch, he prefers deciduous woodland, as do the Tree sparrow and the House sparrow, an adaptable bird who becomes a forest dweller on occasion. The rarer siskin, a yellowish-green finch found chiefly in north-east Scotland, prefers coniferous woods. The buntings, including the yellow hammer, are fond of more open country, but nest on the woodland fringes. Even the finches of the open wastes, such as the linnet, assist the forester by attacking insects in the vulnerable early stages of young plantations, before the young trees have closed-in their canopy. The large, big-beaked, handsome hawfinch is a true woodland dweller, and the pretty goldfinch nests in tall trees.

THE CROSSBILL (*Loxia curvirostra* L.) (92) is a finch whose beak is specially adapted to extract seed from cones, being crossed so as to grip and tear back the protecting cone-scales. The male is crimson in colour, the female greenish yellow. Rather rare, it frequents pinewoods, where its presence may be detected by damaged cones beneath the trees, with their scales torn away, not neatly nibbled as is the case when the seed is stolen by squirrels. Conifers seed abundantly, and seed is seldom required for sowing except when a felling renders it easy to collect, so this interesting bird need not be accounted a forest pest.

WOODPECKERS

At one time the woodpeckers lived under a cloud of suspicion. Ignorant foresters thought that they fed on timber, and persecuted them accordingly. They did not trouble to enquire how the bird digested such a strange diet, nor to speculate why a bird which could feed on such a common commodity was not far more numerous. Actually the woodpecker usually bores into *decaying* timber in search of the grubs of bark-eating and timber-boring beetles. It is beautifully adapted to this work, having a stiff tail which supports it against the tree trunk, a hammer-like head, and a very long tongue, which it thrusts deeply into the bore hole to bring out the grubs. It is a useful bird, and soon makes its appearance where new plantations are established.

The Green woodpecker (*Picus viridis* L.) is a large bird, twelve inches long, green in colour, with a crimson head. In the south of England it is common and conspicuous by its size, the loud laughing cry which has earned it the name of "Yaffle," and its dipping flight from tree to tree. The Spotted woodpeckers (*Dryobates*) (93), patterned in red, black, and white, are rarer, smaller, birds who frequent the tree tops. All the woodpeckers nest in holes in trees.

OTHER TREE CLIMBERS

Other birds adapted to find their food on vertical tree trunks include the **NUTHATCH** (*Sitta caesia* Wolf), which can move about the trunk in any direction, up or down, whilst the woodpeckers can only climb upwards. One of our prettiest birds, it is slate-grey above, yellow and orange below, with a black eye-stripe. It is resident throughout the year, and feeds on insects and nuts, hence the name, meaning "Nut hacker."

THE TREE CREEPER (*Certhia familiaris* L.), a small brown bird with white underparts, is common throughout our woods, residing throughout the year, but it is seldom noticed owing to its habit of clinging to the bark of trees, where it searches for minute insects.

THE WRYNECK (*Jynx torquilla* L.) is a summer visitor to the woods of southern England, where it feeds on ants and similar small creatures found on the bark of tree trunks.

TITMICE

Most of the titmice are pre-eminently woodland birds, specialising in the capture of tiny aphids and similar insects on branches and twigs too small to bear larger birds. They are wonderful acrobats, exploring every inch of twig, bud, and leaf, and most industrious. The Great tit (*Parus major* L.), boldly patterned in black, white, and olive-green, is the most striking, but the smaller Blue tit (*P. coeruleus* L.) is neater and prettier. The tiny Coal tit (*P. ater* L.) is less conspicuous as its main colours are black, brown, grey, and white. It frequents the dryer woodlands, whereas the Marsh tit (*P. palustris* L.), of similar coloration, prefers alder and willow holts. The Crested tit (*P. cristatus* L.) (91) is a rare species found in Scottish pinewoods. All the titmice are resident birds. The word " mice " in their proper name survives from Anglo-Saxon, and has nothing to do with " mouses."

The Long-tailed tit (*Aegithalos caudatus* L.), patterned in brown, white, and pink, is at once distinguished by the great length of its jet-black tail, which serves as a balancer in its difficult feeding operations. It is remarkable for the beauty of its nest, built of moss, lichens, hair, feathers and cobwebs. Throughout the winter months the Long-tailed tits feed in little family parties. Their delicately adjusted tree-top acrobatics are most pretty to watch, as the little group of daintily marked birdlings flit from tree to tree in search of insects and their tiny eggs.

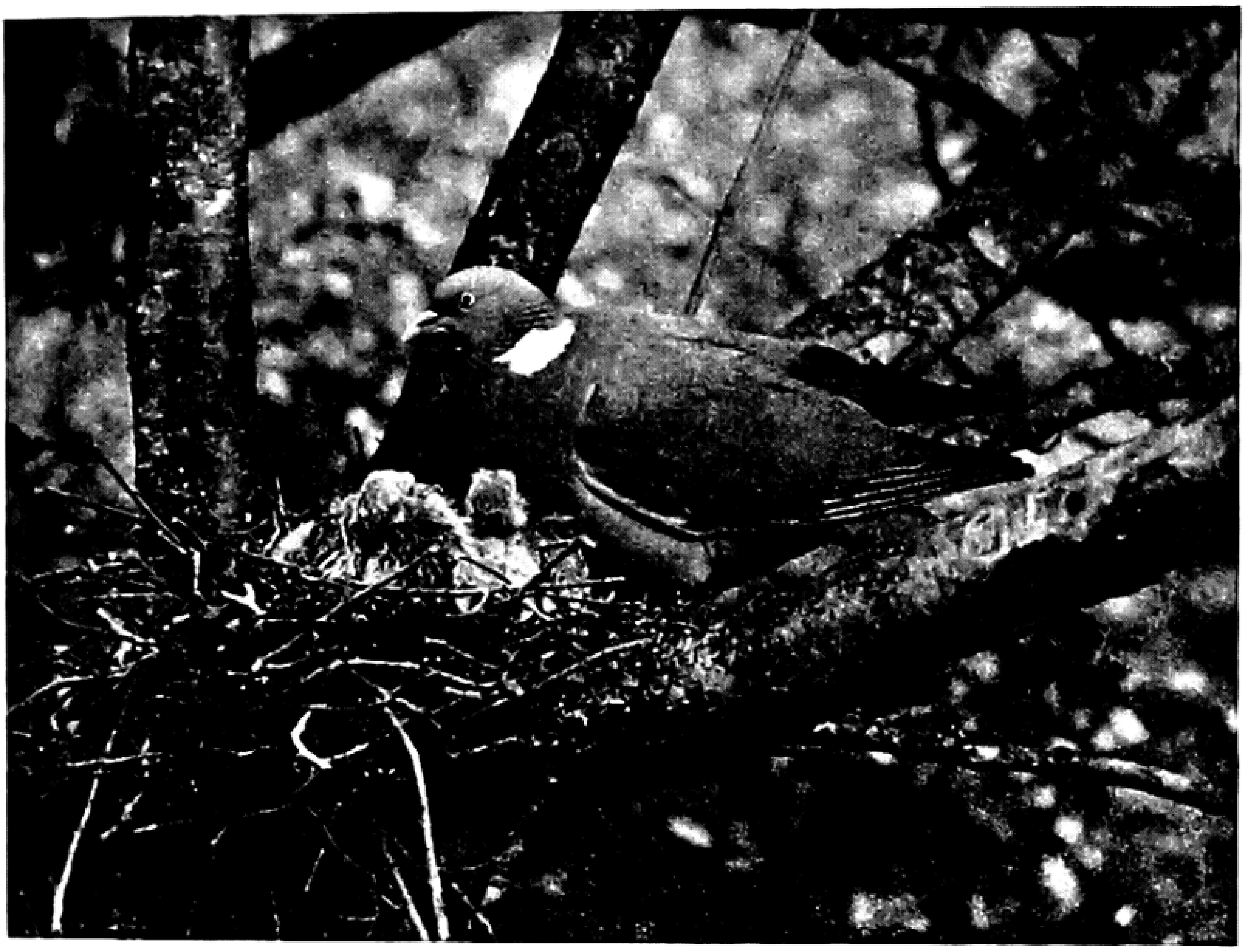
OTHER INSECT FEEDERS

One of our commonest woodland birds is the perky brown WREN (*Troglodytes troglodytes* L.). Only three and a half inches long, it resides with us throughout the year. The wren has little fear of man, and its short, clear, trilling song is often heard at close quarters. It feeds on insects and seeds, and is largely a ground feeder with a fondness for underbrush as a hunting zone.

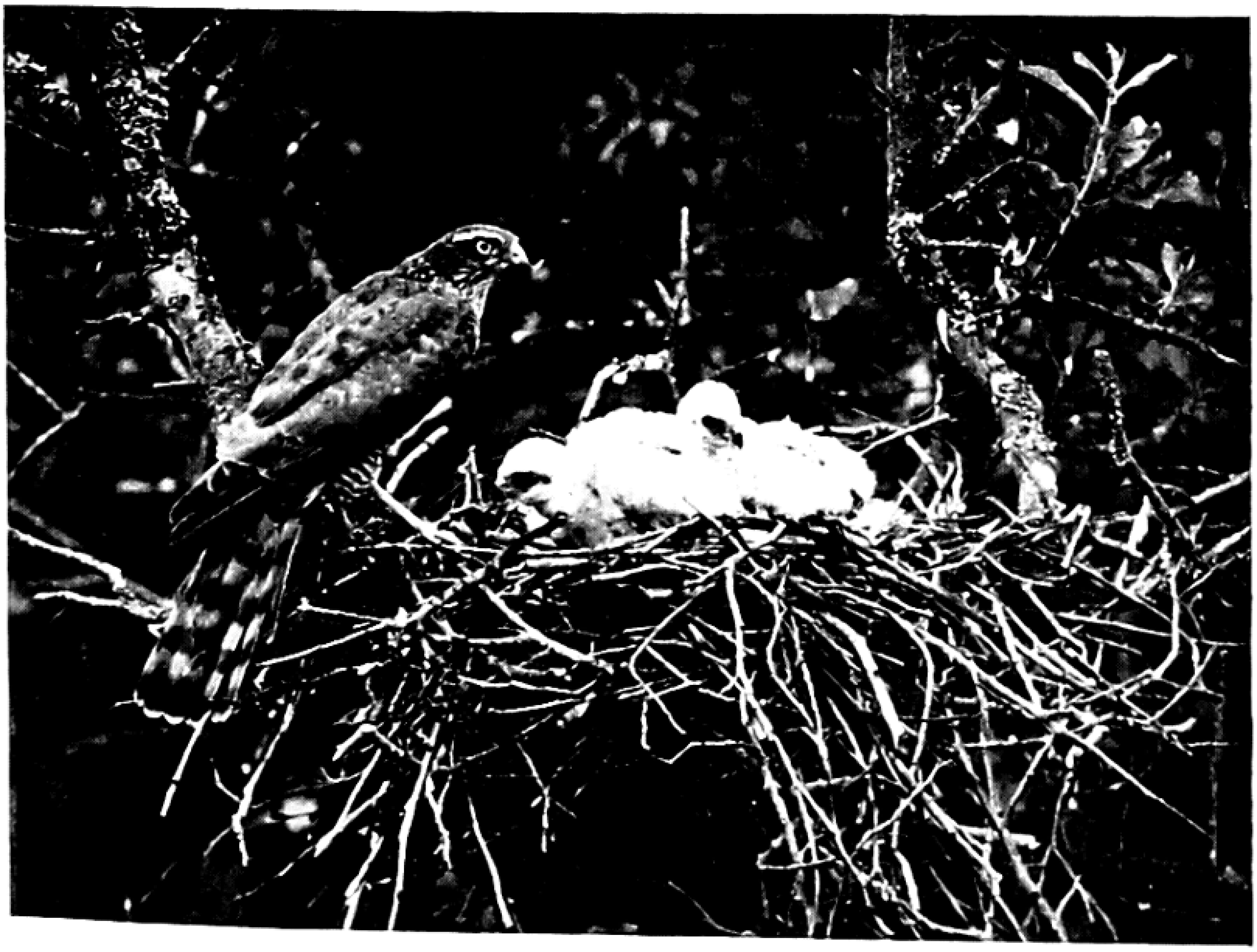
THE WOOD LARK (*Lullula arborea* L.) is a ground feeder which flies up from a perch on the tree-tops to sing on the wing. It is a resident bird, but the rather similar TREE PIPIT (*Anthus trivialis* L.), of much the same habits but more slender build, is a summer visitor only.

Two species of FLYCATCHER occur in our woods. The commonest is the Spotted flycatcher (*Muscicapa grisola* L.), whose dull brown coloration is far less conspicuous than the bright black-and-white markings of the rarer Pied flycatcher (*M. atricapilla* L.). Both are summer visitors who lie in wait for their prey on tall boughs and rise suddenly into the air to catch it with amazing acrobatic flight. The " flies," they catch include all manner of winged insects, mainly injurious ones, so that they are most welcome in the forest.

Another forest dweller is the RED-BACKED SHRIKE (*Lanius collurio* L.) or Butcher Bird, so called from its habit of impaling the smaller birds which are occasionally its victims, on thorns, so that it may eat them at leisure. But it is mainly an insect feeder, and treats large insects in the same way. A summer visitor, it is brightly patterned in red, black, white and grey.

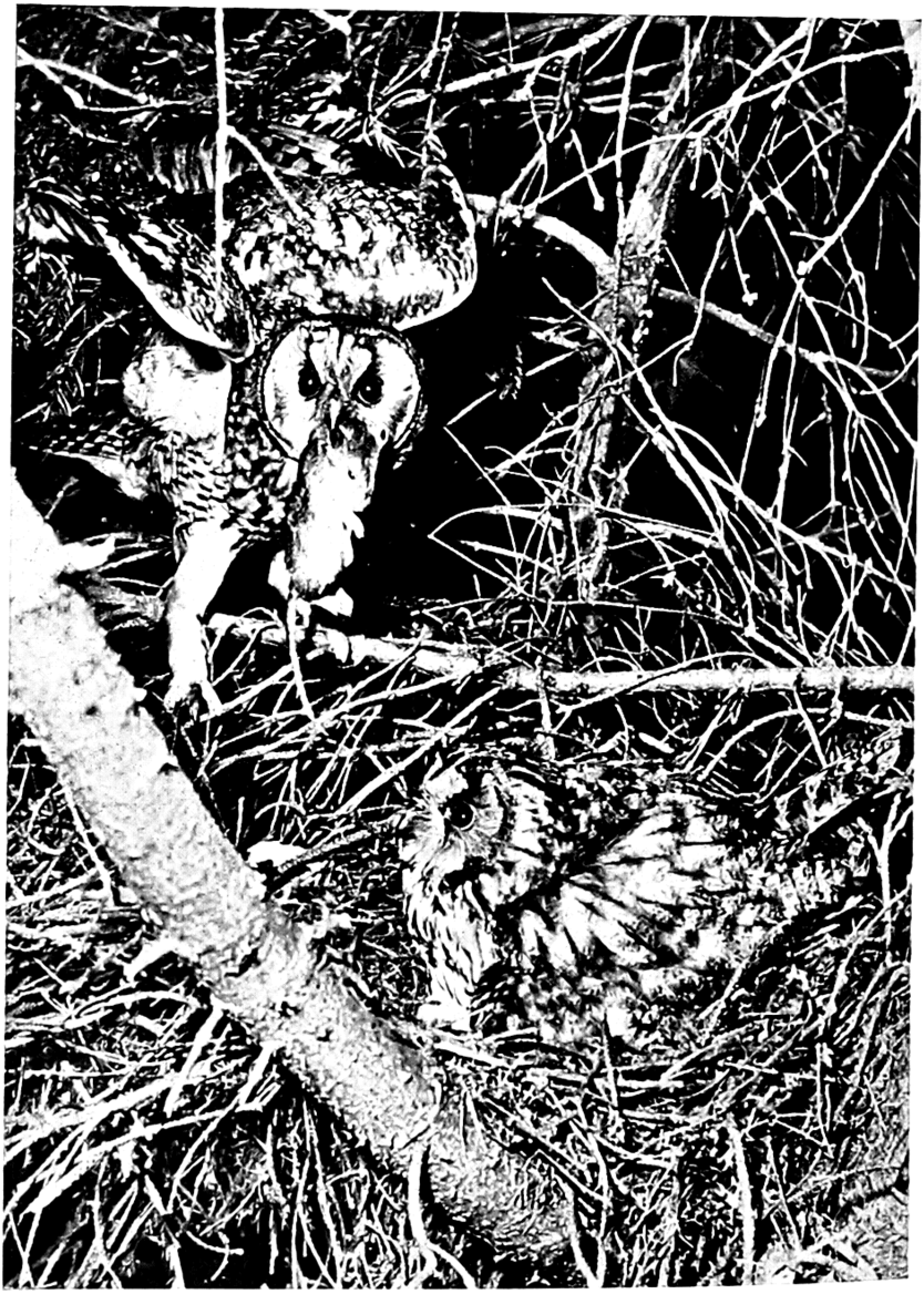


94 RING DOVE



95 SPARROW HAWK

NESTERS IN THE TREE TOPS



96 MALE LONG-EARED OWL BRINGING A YOUNG RAT TO HIS MATE, BROODING YOUNG IN HER NEST IN A SPRUCE TREE

THE NIGHTJAR (*Caprimulgus europaeus* L.), a larger bird, is another summer visitor. Nesting on the ground, where its mottled plumage blends with its surroundings, it makes off when disturbed with a wandering silent flight at a low level. Active only at dusk and dawn, or by moonlight, it catches great numbers of night-flying moths by pursuing them on the wing. It has a curious whirring call.

THE OWLS

Like the nightjar, the owls are large nocturnal birds of silent flight. The larger species prey largely on rats, voles, and mice, and are of great value in restricting the numbers of these rodents to a level at which they do no effective damage to the forest. Insect food also bulks largely in their diet. The principal woodland species are the Tawny owl (*Stryx aluco* L.), a nester in hollow trees whose eerie hooting resounds through the groves in early summer, and the Long-eared owl (*Asio otus* L.) (96) which prefers the pinewoods of Scotland. The ghostly white Barn owl (*Flammea flammea* L.), or Screech owl, uses trees both for nesting and as a hiding place throughout the year. Most owls like the hollow heart of old trees as a place of concealment. The Little owl (*Athene noctua* Scopoli), an introduced species, hunts by day as well as by night, and is a useful hunter of the larger insects.

BIRDS OF PREY

We have dealt so far with birds which feed upon plant life, insects, or small animals, and have found their activities largely beneficial. But the hawks and allied birds of prey feed in part upon other birds, and one must consider carefully in the case of each species whether it does more good than harm. Only certain of the hawks frequent the woods, others preferring the open country.

THE SPARROW HAWK (*Accipiter nisus* L.) (95) is a relentless hunter of small birds of all kinds. The gamekeeper restricts its numbers to save his pheasants, and the forester can also run up a heavy score against it on account of its destruction of useful birds of all kinds. But the KESTREL (*Falco tinnunculus* L.) known by its hovering flight, preys upon mice and insects, and may be welcomed in the forest. The big eagle-like BUZZARD (*Buteo buteo* L.) is also comparatively harmless, but its size (it is nearly two feet long) has led to its being persecuted to the point of extinction over most of Britain. It has a graceful gliding flight, and a curious call like the mewing of a cat.

THE GOLDEN EAGLE (*Aquila chrysaetus* L.) is by nature a forest dweller, and will nest in tree tops. But in Britain it has been banished to the treeless wilds of the remoter Scottish Highlands, where it haunts the open country, and more frequently nests on cliff sides.

THE CUCKOO (*Cuculus canorus* L.), though not strictly a bird of prey, has much the same effect on the bird life of the woods. As is well known, the hen cuckoo lays a single egg in the nest of some small bird, generally a valuable insect eater. After hatching out, the young cuckoo throws its foster-brothers out of the nest, so that they perish. Instead of half a dozen young warblers, a single cuckoo is raised. Against this damage, there must be reckoned the fact that the cuckoo is a voracious feeder. In its nestling stage, it consumes quite as many insects, obligingly caught by its foster-parents, as their own brood would have done. As an adult, it feeds largely on hairy caterpillars which few other birds will touch, and having no " home ties," ranges far and wide across the countryside in search of these. On balance therefore, its account is clear. It provides a useful substitute for the other birds which it so parasitically supplants. A summer visitor, this large grey bird with his black and white barred breast, is very common in the woods where his clear mating call of "Cuckoo! Cuckoo!" resounds throughout the early summer.

THE ENCOURAGEMENT OF BIRD LIFE

With such rare exceptions as the Sparrow hawk, bird life is beneficial to the growth and spread of woodlands. The argument for this is direct and clear. Trees provide a feeding ground for an enormous number and variety of insects, which all possess powers of very rapid multiplication. Should these at any time get the upper hand, that is to say, should the tree-feeding vegetarian insects exceed the ability of the carnivorous parasitic and predatory insects to control them, the trees will be destroyed. This rarely happens in Britain, but in Germany, between 1853 and 1863, twenty-one thousand acres of coniferous forest were destroyed by the tiny Nun moth (*Liparis monacha* L.). Against such disasters the birds provide an ever vigilant "police force," able to cope with any increase of insect life. The problem, then, is how to encourage them.

Legal protection of all desirable species is the first step, and happily most useful birds are now protected in Britain. The provision of nest boxes aids the birds at a critical stage of their life history, and promotes an increase in the number of young successfully raised each year. The planting of ornamental shrubs on the outskirts of the forest provides additional nesting sites and also some variety in food, particularly if berry-bearing species are employed. All birds benefit by quietness and privacy during their nesting season. Winter feeding is another possible means of aid, for a long spell of hard weather severely reduces the number of birds who survive until the next summer. There is abundant scope for studying the best means to promote the welfare of each species.

A further effect of bird life on the growth of woodlands, is their share in seed distribution. Some succulent fruits, such as hawthorn and yew berries, contain seeds that are so constructed that they can pass unharmed through the bird's digestive system, and germinate wherever they are ultimately dropped. So the birds enable these trees to spread far and wide. Other seeds, such as acorns and silver fir, are normally destroyed if eaten as food, but may also be accidently distributed. The forester bent on collecting seed for his own sowings, often finds the birds are active competitors.

Even more important than their work in the woods, is the part played by tree-nesting birds in the control of agricultural pests. Taking a list of 43 birds notably helpful to the farmer, it is found that 32 nest in trees and hedges, and that 21 are predominantly woodland haunters who frequent the fields and gardens to feed. Our woods and copses play a significant part in affording shelter and nesting sites to the birds which keep our agriculture singularly free from insect plagues.

Before new woods arise to their full stature they frequently shelter the birds of the moors and wastes that the trees replace. Lapwings and curlews continue to haunt the fringes of new forests in the hills, retreating only slowly to the barer upper levels, and retaining nesting sites wherever a gap is left in the ranks of young trees. Stone curlews have persisted in Norfolk in the midst of widespread afforestation. Snipe too, keep a foothold where the marshes remain undrained; whilst the little black-and-white dipper flits to and fro above the burns long after the trees have raised their leafy canopy around them. There is so much treeless land in Britain that ornithologists tend to rank most ground-nesting birds as "open country" species, whereas many, such as partridges, are quite at home on the fringes of woodlands.

Recent observations suggest that the trees most favoured as nesting sites by many of our smaller birds are the Norway and Sitka spruces, both introduced conifers. It is possible that the forester, by planting thousands of "desirable building sites" throughout the country, may cause a significant increase in our population of song birds.

Some of the water birds thrive in well-wooded country, which gives them shelter and helps to increase their food supply, for the aquatic animals that form their food are themselves nourished by the fall of the trees' leaves. Wild duck, or mallard, are commonly found on small sheets of water hemmed in by woodland, and will at times nest in low trees. The black, red-billed water hen is another wood-and-water bird that will not only nest in low bushes but also roost and feed there; it makes its home beside all but the smallest of forest pools. Even the lordly heron will often carry his fishing forays far into the woods, where he may be surprised as he stands silently beside some babbling stream. The brilliant kingfisher, too, launches his dazzling, lightning swoops upon the little fishes from the boughs of the alders and willows of the riverside.

There is thus a wide range of species and a rich variety of modes of life amongst the woodland birds, which adds interest to the work of every observant forester.

CHAPTER 11

FOREST ANIMALS

Most of the larger animals found wild in Britain are creatures of the forest, relying on its cover for concealment from their enemies, the chief of which is man. Their natural food supply is varied, ranging from tree products such as nuts, to grass and seedling trees, insects, and, in the case of carnivorous animals, the flesh of other mammals and birds. The nature of their dietary decides whether each forest animal is to be classed as useful or harmful.

A fundamental natural law appears to govern the effect which certain creatures have upon their habitat. True woodland animals, such as deer, cattle, and swine, *so long as their numbers are restricted by their natural enemies,* do not harm the forest to any serious extent. If they did do so, they would destroy their habitat, and their race would suffer accordingly. This law can only operate to a limited extent in Britain, for the natural enemies of these animals, wolf and lynx, have been exterminated by man.

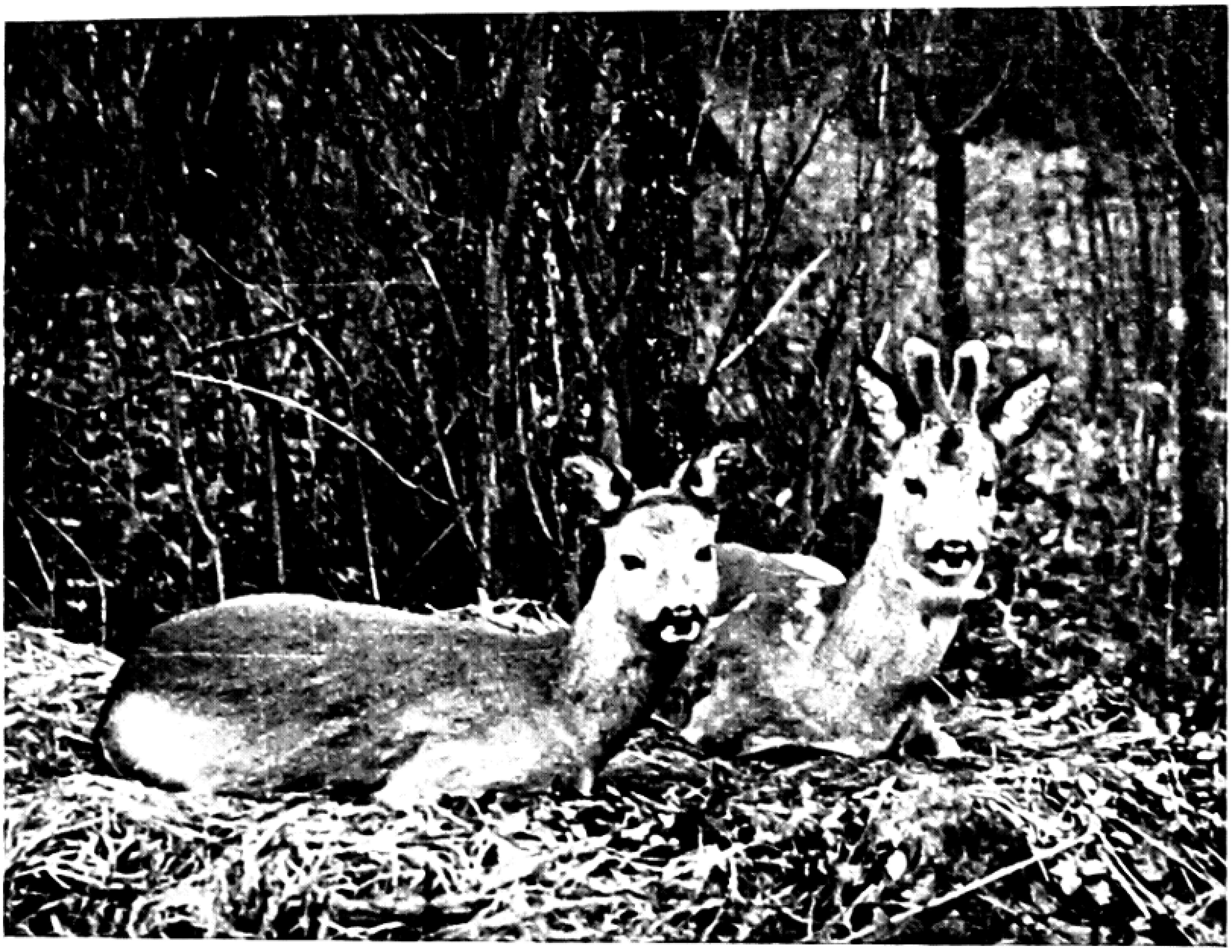
Conversely, creatures of the plains, such as the rabbit, hare, sheep, goat, and horse, damage the woodland, for their feeding habits are adapted to grassland, which is their natural home. In an undeveloped country, they shun the shade of trees, for they rely for safety on speed and a keen observation. But if they are protected or domesticated by man, and kept either through fear or by enclosing fences in wooded country, the damage they do is devastating.

This chapter deals mainly with *mammals*, that is, the warm-blooded, four-footed beasts which bear living young and suckle them. Cold-blooded vertebrate animals are comparatively unimportant in our temperate climate. They are obliged to *hibernate*, that is, to sleep throughout the winter, in order to survive the cold. Frogs, toads, and newts are insect-eating *Amphibians*. The toad (*Bufo bufo* L.) is common in woods, where it does useful work by feeding on grubs. Of *Reptiles*, the lizards usually prefer more open country, with the exception of the legless Slow Worm (*Anguis fragilis* L.) found in the woods of southern England. Three species of snake, the harmless Grass and Smooth snakes and the poisonous adder, are occasionally encountered in wooded country. All these reptiles include insects in their dietary.

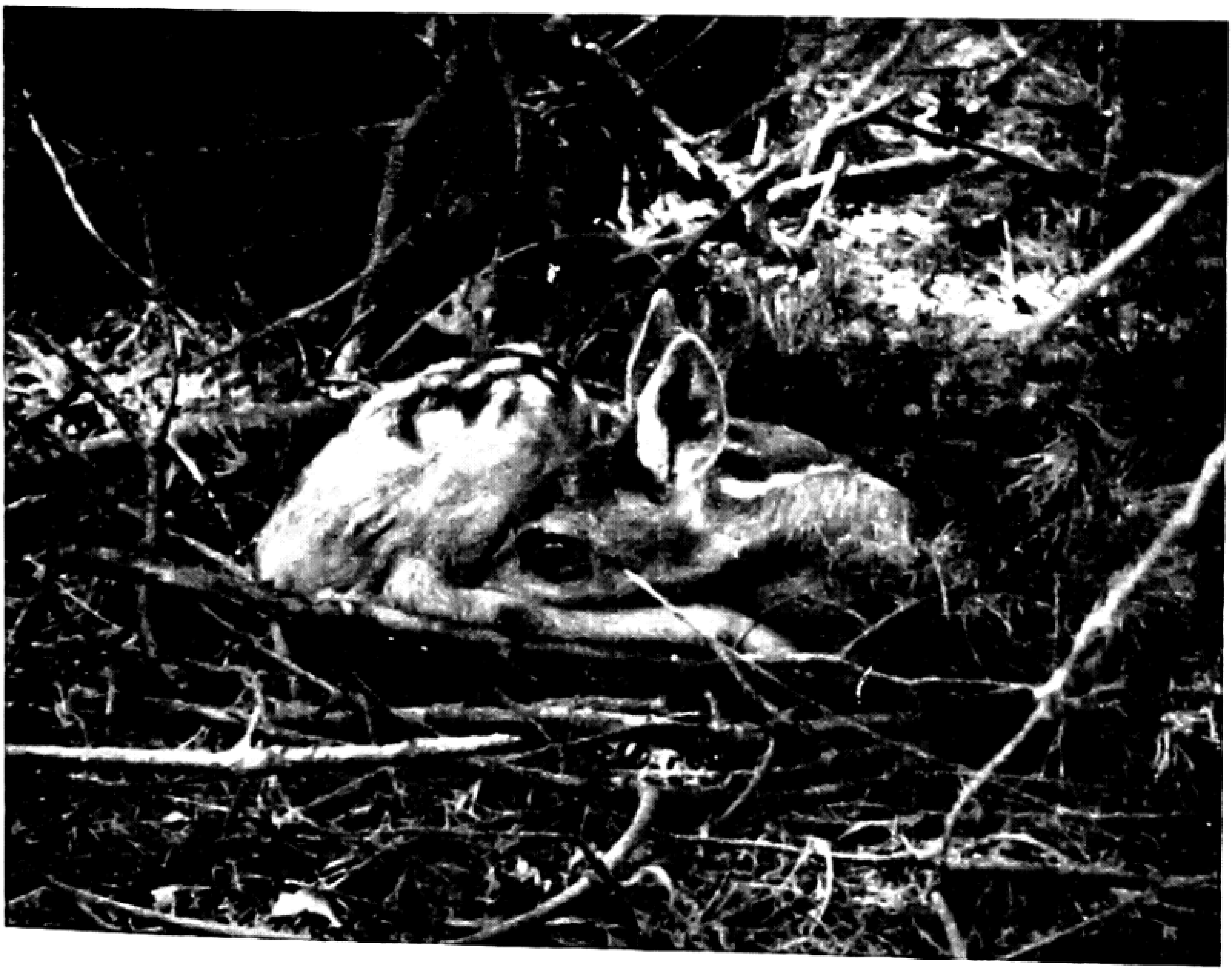
DEER

Deer, our largest remaining wild mammals, are true woodland dwellers. Those who have seen the Red deer in the so-called " deer forests " of Scotland, which are mountainous treeless wastes, might query this statement, but the heather-clad mountains are not the true home of this noble creature. They are merely its last resort now that the glens have lost their natural vegetation of pine and birch forest. This type of country is ideal for the sport of deer-stalking, so that the deer are protected there, and in many cases confined to a single property by enclosing fences.

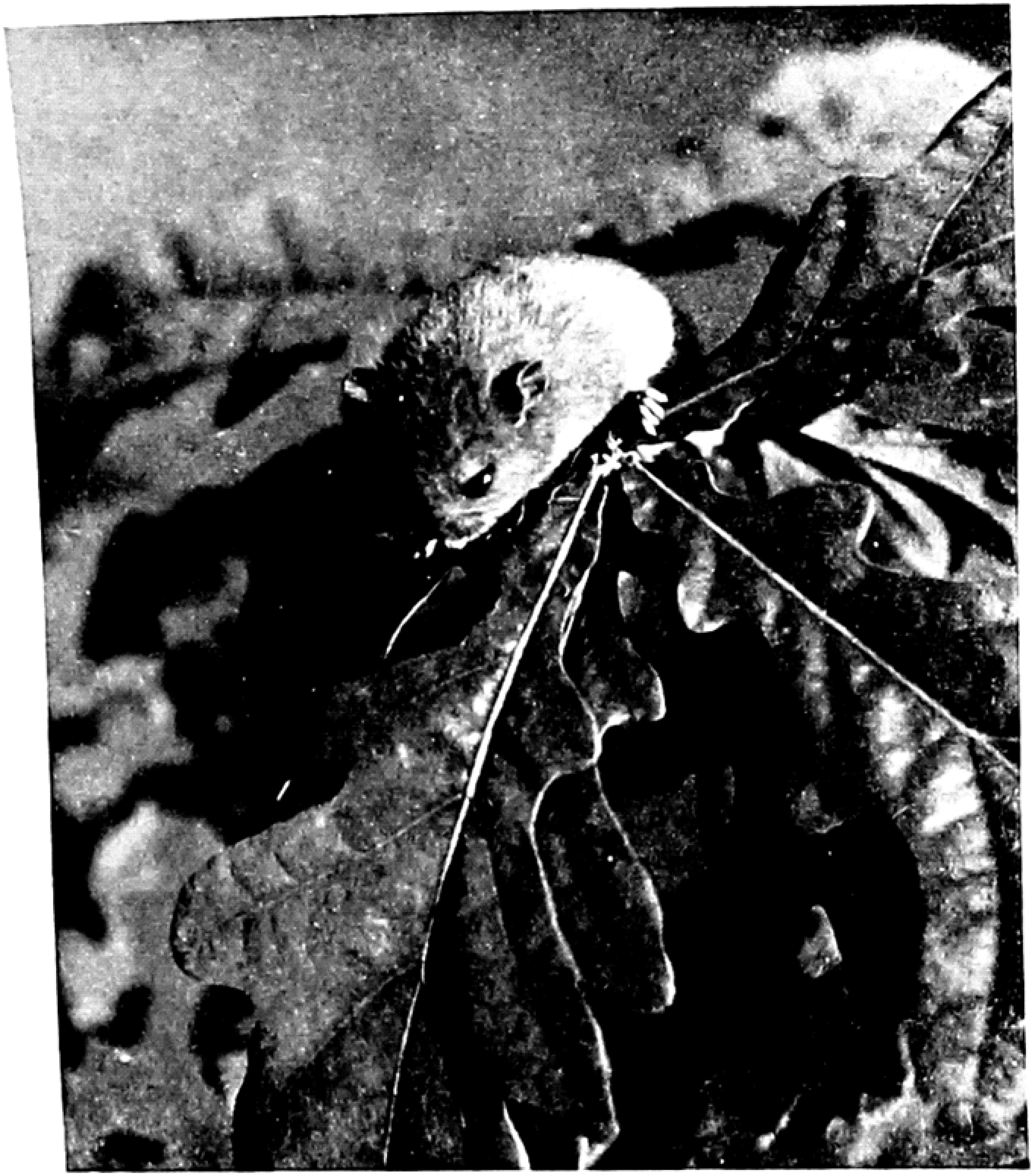
There are now at least six species of deer running wild in Britain. At different times importations and transportations of all of these have occurred, but three may be regarded as true natives of the whole island, whilst the other three are recent introductions from Asia. All are kept in a semi-domesticated state in parks, but it is with the true wild deer that we are here concerned.



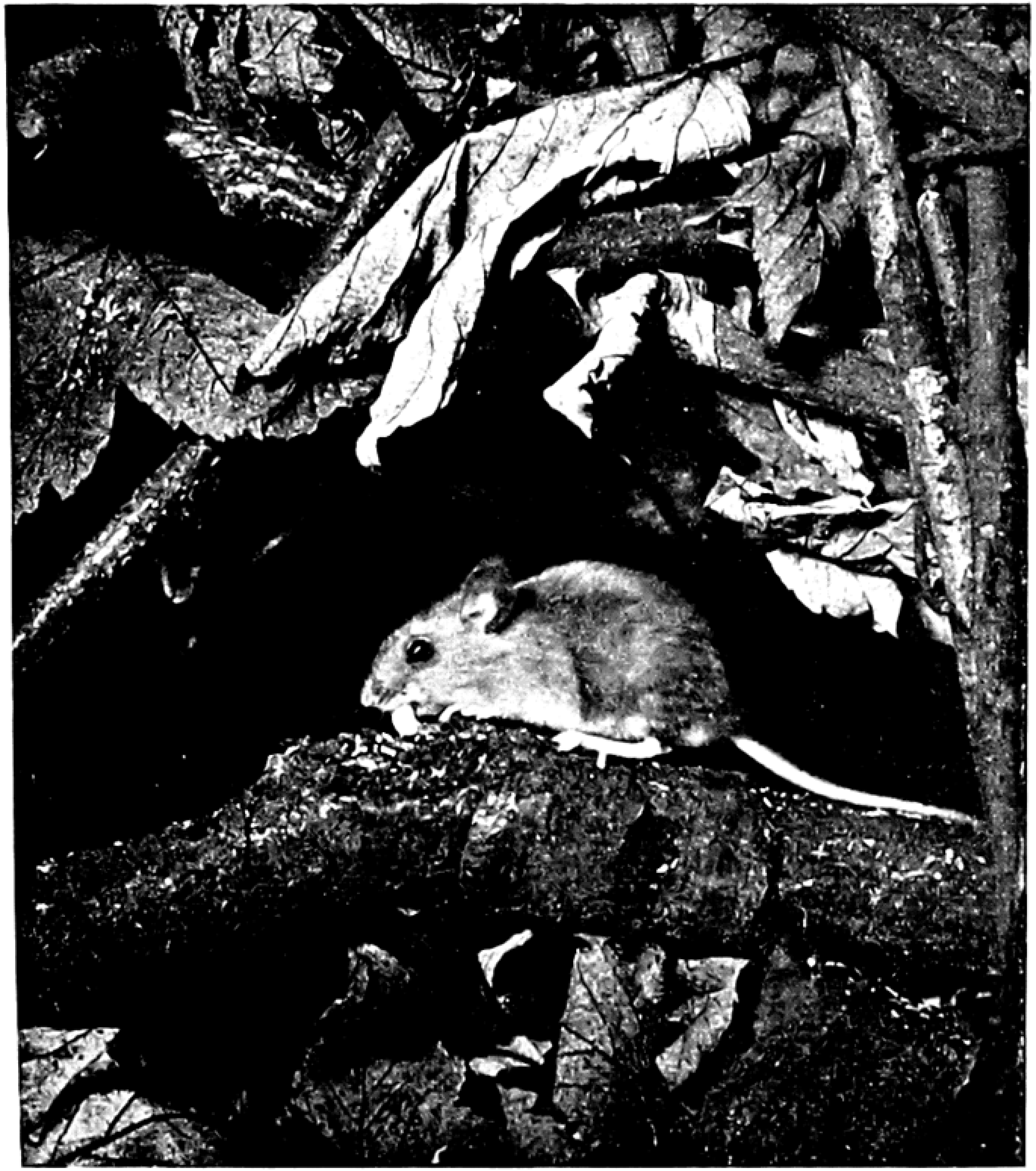
97 A PAIR OF ROE DEER; THE BUCK HAS HIS HORNS "IN VELVET"



98 A ROE DEER FAWN



99 DORMOUSE, *MUSCARDINUS AVELLANARIUS*



100 WOOD MOUSE, *APODEMUS SYLVATICUS*

Deer are hoofed animals (*Ungulates*), and ruminating animals that chew the cud. They are strictly vegetarians, feeding mainly on grass and herbs; they are selective in their feeding, and do not often attack trees, other than seedlings, unless other food is scarce or difficult to obtain. Even so, they have their preferences. Thus, in hard weather they love to browse on young beech branches, and the resinous bark of Douglas fir has a singular attraction for them; they rip it up from young trees, but older Douglas firs are seldom attacked (138). The damage they do is usually confined to young seedlings and transplants. The forester is therefore obliged to keep them out of the area of his operations by a six-foot fence, for they are great jumpers, or else to limit their numbers by shooting, usually with buckshot from a shotgun.

Deer-stalking and deer-hunting do not effectively restrict the numbers of the deer. The aim of the sportsmen in each case is the male deer or " hart." The females, or " hinds," are often allowed to go unmolested, and as they are polygamous, soon find another mate. Deer mate in autumn. This is their " rutting " season, when the stags bellow through the woods and fight great battles among themselves. At this time they are dangerous to approach. The young fawns, which are born in spring, are at first helpless, but soon learn to follow the does (98). The antlers of the males (known variously as stags, bucks, or harts) grow annually, appearing as velvet-covered knobs in spring, developing into hard bony structures by autumn, and falling every winter. Their size and number of " points " indicate the age and vigour of the male stag, but very old stags carry poor heads. Venison, the flesh of the deer, is in season in winter, and when properly cooked is of a most attractive flavour.

THE RED DEER (*Cervus elephas* L.) is the largest species, standing 4 feet high at the shoulders. It is now confined as a wild beast to the Scottish Highlands and south-western England. It is usually brown in colour, but the fawns are dappled. Its much-branched antlers lack the flattened blades that distinguish the FALLOW DEER (*Dama dama* L.), a commoner species. This is somewhat smaller, standing 3 feet high at the shoulder, and is prettily dappled in shades of light and dark brown—a protective camouflage well suited to the woods. Similar, but larger and darker in colour, is the Japanese deer (*Sika nippon* Temm.), an escape from captivity now naturalised in Hampshire and Dorset.

The still smaller ROE DEER (*Capreolus capreolus* L.) (97, 98), only 2 feet to the shoulder in height, differs from its allies in being monogamous, living in pairs throughout the year. Its small pointed antlers add to its quaint elfin beauty, and it is a graceful active animal, seldom seen on account of its wariness and the dense undergrowth in which it loves to hide.

A similar species is the Siberian Roe deer (*Capreolus pyargus* Pallas) now naturalised in the Midlands. Another escape from captivity which thrives and appears to breed in a wild state is the Chinese Muntjac or Barking deer (*Muntiacus reevesii* Ogilby) and it is possible that further foreign species may have spread from English parks to the woodlands.

All deer feed at dusk and dawn for preference, sleeping in concealment throughout the day. Their presence in the woods is often only revealed by their distinctive hoof-prints, droppings, and occasional damage to young trees. As they have now no natural enemies, their numbers must on occasion be restricted by deer drives or shoots. But so long as their numbers do not become excessive, the toll they take of forest and farm crops is a light one.

THE RABBIT

The same cannot be said of the wild RABBIT, Coney, or Bunny, (*Oryctolagus cuniculus* L.). This ranks as the deadliest foe of the forest, the one creature that can never be permitted in young plantations, even in the smallest numbers. The reason is simple and clear. Naturally a creature of the grass country, Brer Rabbit eats everything down to ground level, disdaining only a few distasteful herbs. Grasses survive this ruthless treatment. Young trees are exterminated by it (136).

The rabbit is not a native, having been introduced for food and sport, probably by the Normans. Our mild climate is much to his liking, and in our small island many of his natural foes are exterminated or nearly so, in the interests of game protection. Few animals breed so freely. Litters of young appear throughout the spring and summer months, sometimes at other seasons of the year. There are around eight young in each litter, six or more litters a year. The young, born blind in burrows, breed themselves when six months old. Not all the depredations of fox, stoat, weasel, and hawk, can keep pace with this terrific rate of increase. Man joins in the attack with gun, dog, ferret, snares, nets, traps, and even poison gas. The rabbit retires from the cultivated lands to the woods and wastes, forms fresh colonies, and resumes his attempts to re-populate the world with his multitudinous progeny.

Fortunately for both forest and forester, he is baffled by wire netting. This must be three and a half feet high, with the lowest six inches turned out towards the rabbit-haunted land at right angles, and either pegged down or buried below sods; otherwise Brer Rabbit will burrow beneath it. The mesh must be fine, no bigger than one-and-a-quarter inch, otherwise his youngsters will slip through. And the whole fence must be patrolled at regular intervals to check gaps or damage. The rabbits within the fenced area are then exterminated, and the trees may be planted in safety. Wire-netting fencing adds greatly to the cost of tree-planting in Britain, but in most districts it is essential. Otherwise the rabbits eat every young tree.

The tame rabbit is an attractive creature, and his wild cousins in the woods and farmlands receive a certain amount of misplaced sympathy. If all rabbits lived in hutches or enclosed warrens, the demands for flesh and fur could well be met without prejudice to farm or tree crops. But the presence of wild rabbits is harmful to agriculture and fatal to good forestry.

HARES

THE BROWN HARE (*Lepus europaeus* Bell) and the MOUNTAIN HARE (*L. timidus* L.) cannot be kept out of plantations by ordinary netting fencing, for they jump it with ease. Fortunately they prefer open country, and only cause occasional damage in young plantations, chiefly in winter, when the tips of the trees show above the snow. Both rabbits and hares are curiously independent of water supply, finding enough from dew and vegetation.

MICE AND VOLES

Two species of true mice frequent our woods. In general build they resemble the House mouse, that is, they have pointed noses and long tails. The commonest is the WOOD MOUSE (*Apodemus sylvaticus* L.) (100) also known as the Long-tailed Field mouse. The YELLOW-NECKED MOUSE (*A. flavicollis* Melchior) is larger, and fiercer in its hunting habits; it is distinguished by the yellow fur that almost encircles its neck. Otherwise both species are typically

" mouse-coloured " above, but paler beneath. Both are true woodland dwellers, frequenting the undergrowth in search of seeds, nuts, berries, and green shoots. They construct nests concealed in low bushes, and made of grass and leaves. But although several young are born in each litter, they have so many natural enemies that they seldom become obviously harmful to the forest.

The same is true of the DORMOUSE (*Muscardinus avellanarius* L.) (99), a quaint creature midway between the mice and the squirrels. It has a large bushy tail, and feeds for preference on nuts. In winter it hibernates, sleeping for three or four months in a cosy ball of grass and leaves. Dormice are nocturnal in habits, seldom seen, and do no serious damage.

The voles are distinguishable from the true mice by their blunt heads, stocky bodies and short tails. Two species, the WATER VOLE (*Arvicola amphibius* L.) or Water rat, and the BANK VOLE (*Clethrionomys glareolus* Miller) frequent wooded country near streams, and do comparatively little harm. But the commoner FIELD VOLE (*Microtus agrestis* L.) is a dweller amongst field crops throughout the summer, and when he resorts to the woods after these are harvested, can do severe damage to young trees by eating their bark until they perish through girdling of the stems. Possessed of great reproductive powers, a single pair may produce 10,000 descendants within a year. From time to time, their numbers get out of control, and " Vole Plagues " occur. The numerous natural enemies of voles include such forest-haunters or nesters as weasels and owls. Thus the woodlands play a part in restricting the spread of this pest of the farmlands.

Mice of all kinds can be most destructive to forest tree seed when it is sown in nurseries. For this reason, conifer seed is always dusted with poisonous Red Lead before sowing, and the mice then usually avoid it.

The Brown rat is occasionally encountered in the woods, but it prefers the richer feeding grounds of farmlands and towns, and seldom becomes numerous away from such man-made food supplies.

SQUIRRELS

No creature is more typical of the woods than the RED SQUIRREL (*Sciurus vulgaris* L.) (101). Beautifully adapted to tree-top life, he frisks gaily up or down vertical trunks or leaps from tree to tree with the agility of a bird. Feeding for preference on nuts, he is equally at home in coniferous forests, where he gnaws the cones with his chisel-like incisor teeth to obtain the nutritious seed. His fur is warm russet-red in colour, and the long bushy tail serves as a balancer during his arboreal antics. He builds his nest or " drey " high in the branches of a tall tree. The young are blind at birth, and only one litter is produced each year. In the north, squirrels may sometimes hibernate for short cold spells, but in southern England they remain active throughout the year.

Although the food of the Red squirrel is tree seeds, these are produced in such great abundance that his share can usually be spared without detriment to the forest. He makes stores for winter use, and if these are forgotten, the nuts germinate, and new trees arise. Exceptionally, squirrels become too thick upon the ground and cause serious damage to tree-tops by girdling the young bark and also by eating out buds, but in reasonable numbers they may be tolerated as dwellers in the woods.

THE GREY SQUIRREL (*Sciurus carolinensis* Gmelin) (102) is unfortunately far less welcome to forester, farmer, or gardener. Introduced from North America and readily recognisable by his more rat-like build and grey fur, his feeding habits are often harmful. He likes buds and young shoots, fruit, bulbs, birds, eggs, seeds, and grain. To conifers he does little harm, though in spring he finds beech and sycamore shoots curiously tasty (137). He emerges from the woods to do damage in the garden and orchard. Man's hand is therefore against him, for he has few natural enemies in Britain, and his numbers increase with alarming speed.

The feud that exists between the Grey and the Red squirrels has been exaggerated. In North America both Red and Grey squirrels occur, neither exterminating the other. Their feeding grounds differ. The Grey squirrel prefers the woodland fringes near dwellings and cultivation. His red cousin likes the true forest depths, and although in consequence he is less often seen, he is holding his own in many parts of the country.

Another potential denizen of our woods is the American CHIPMUNK (*Tamus striata* L,). which has been reported in a naturalised state near London, but is still a rarity. It may be recognised by its black and white markings, and is a " ground squirrell," able to burrow underground.

INSECTIVOROUS MAMMALS

Thus far we have dealt with mammals which are mainly vegetarian. The small but interesting group of insect-eaters do useful work by devouring harmful insects both at ground level and in the air.

Most conspicuous is the HEDGEHOG (*Erinaceus europaeus* L.) (104), an active nocturnal hunter throughout the summer months. In autumn, when insects get scarce, he seeks some secluded retreat, rolls himself into a ball, and hibernates until the spring.

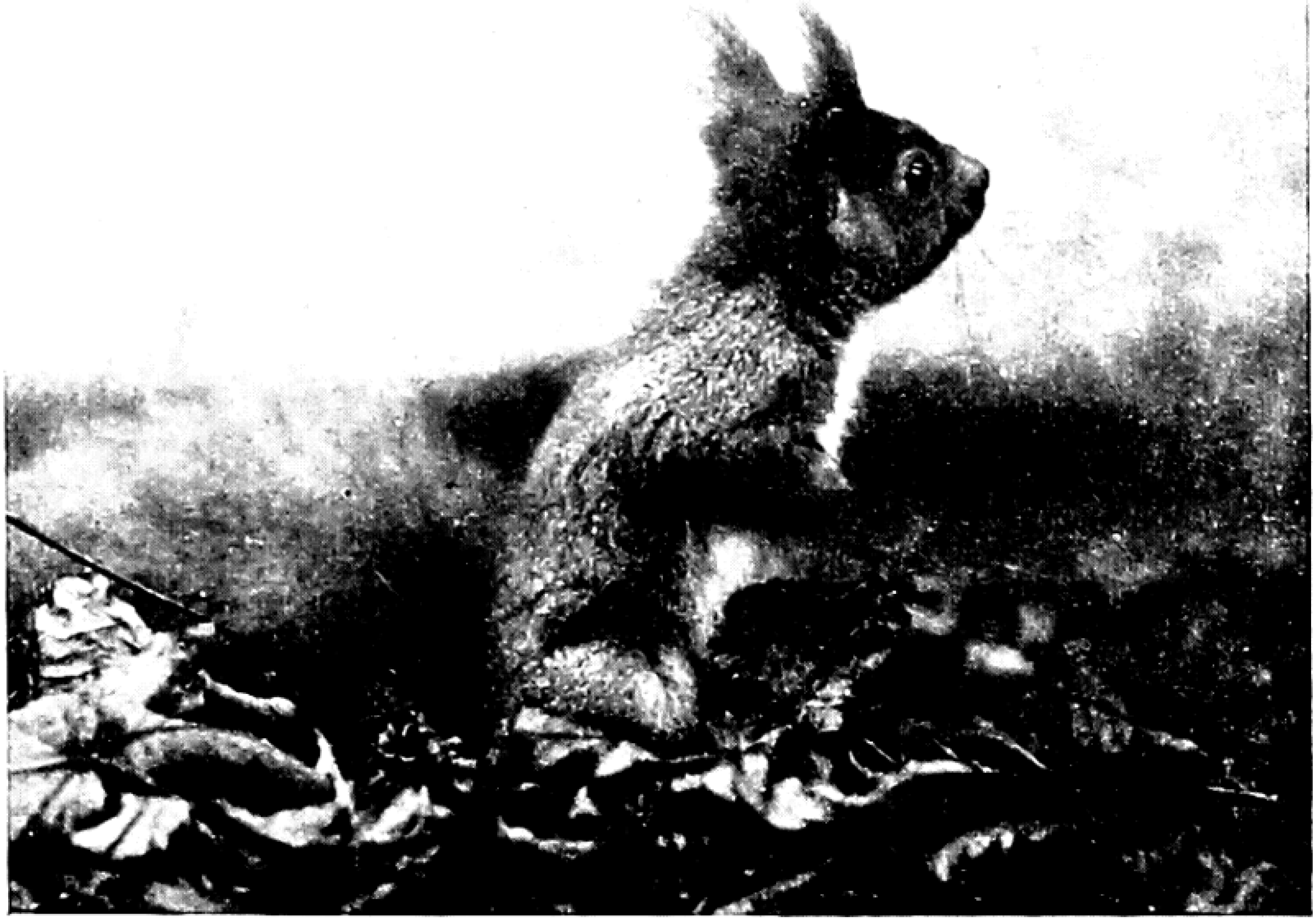
The little, sharp-nosed SHREWMICE are active throughout the year. Three species occur, the Water shrew, the Common shrew (*Sorex araneus* Bell), and the Pygmy shrew, which is only two-and-a-quarter inches long, and our smallest British mammal.

THE MOLE (*Talpa europaea* L.) continues the hunt for worms and insect grubs below ground level. Where he breaks into a forest nursery, his runs cause havoc in the seedbeds, so that the forester is obliged to set spring traps to catch him in his underground tunnels.

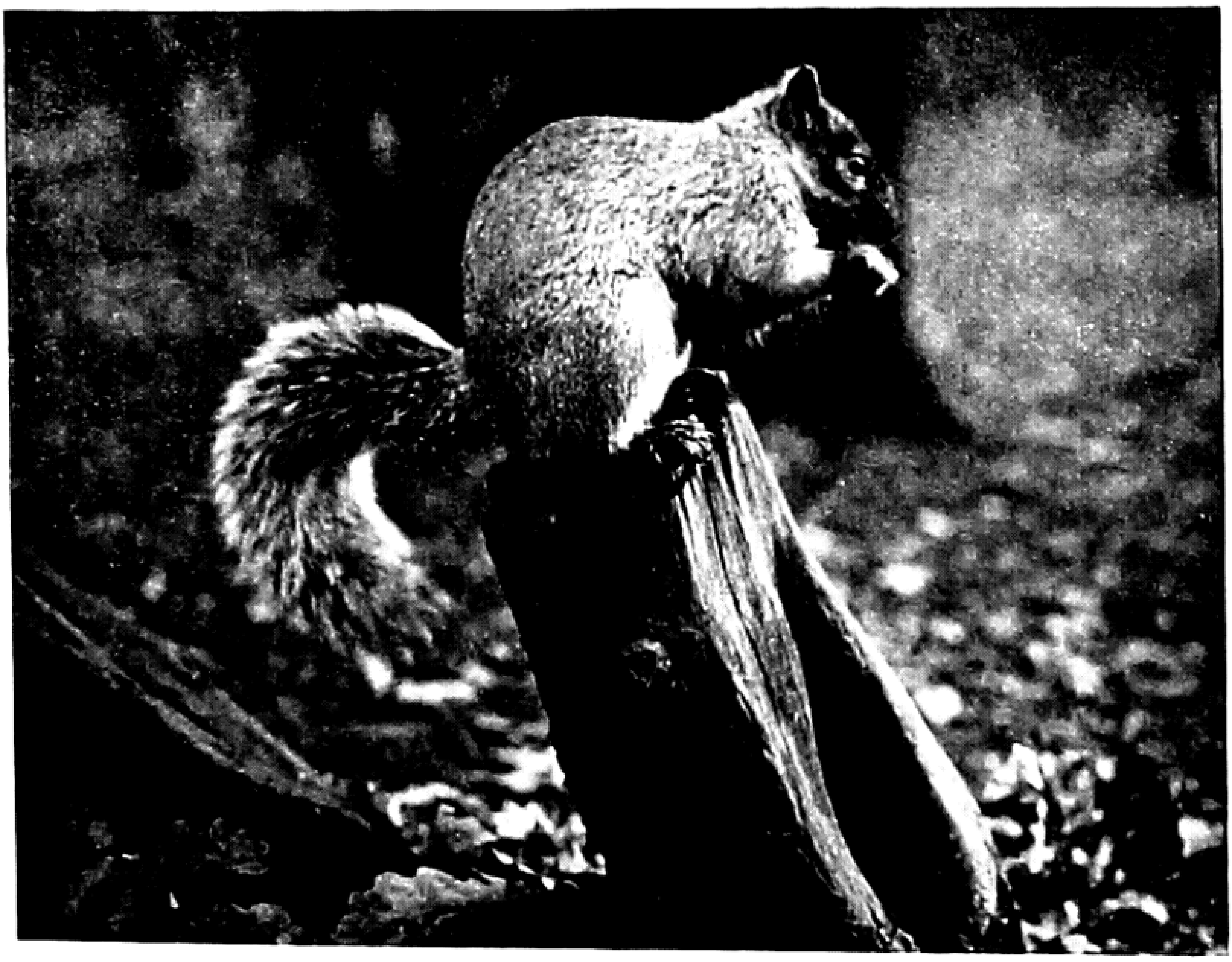
Also insectivorous are the winged BATS or Flittermice (*Chiroptera*) which catch their prey by night upon the wing. Twelve British species have been identified by experts. During the day they hide in holes in rocks, buildings, or trees, hanging head downwards. In winter, when insects fail, they hibernate. The female carries her young through the air with her. All are small creatures, a few inches long. They do useful work in the woods, where they are usually common.

CARNIVOROUS MAMMALS

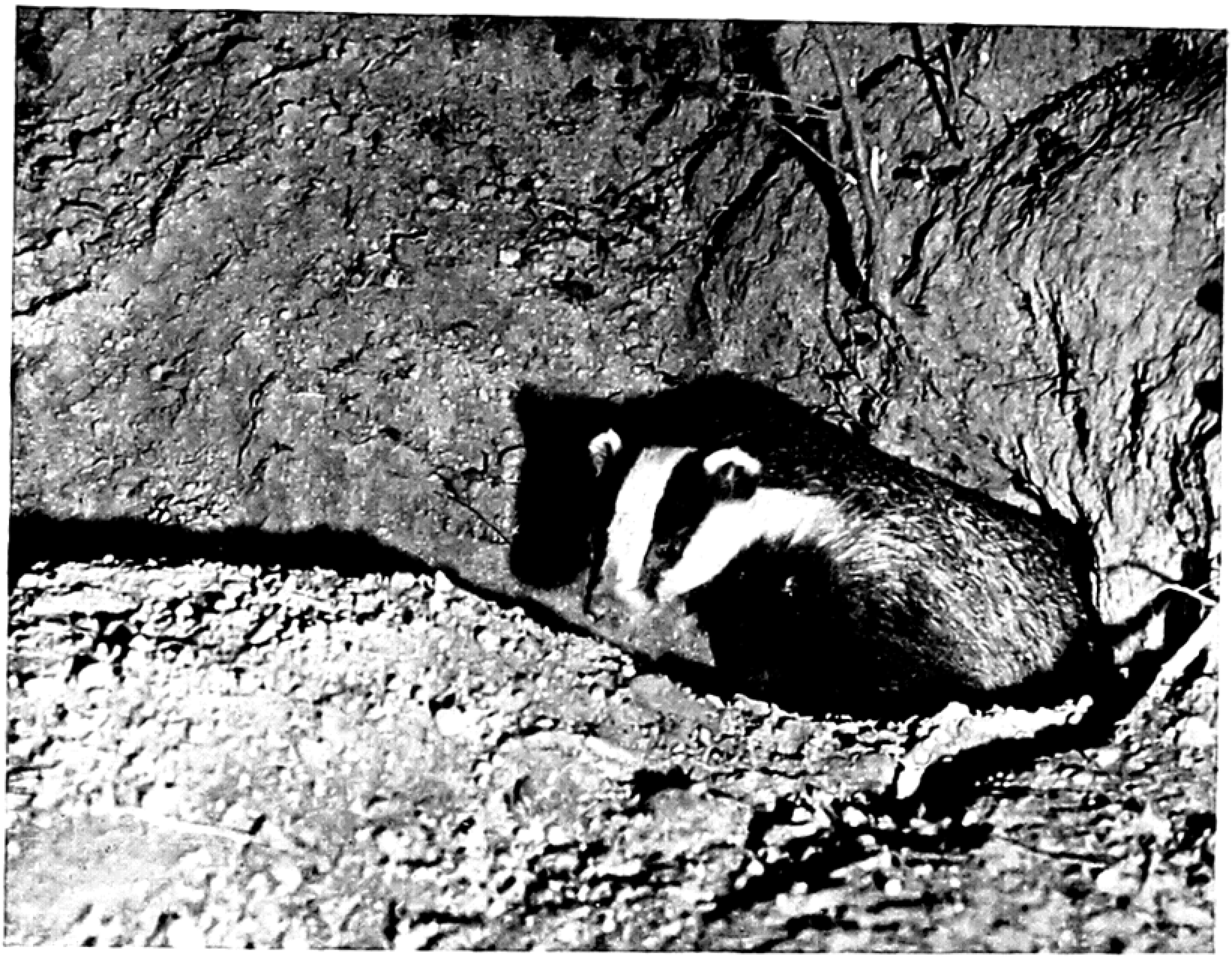
The flesh-eating mammals are in general useful to the forest, since they restrict the numbers of the vegetarian rabbits, mice, and voles, which would do serious damage if allowed to increase unchecked. The most numerous and active are the weasel tribe, typified by their slender snake-like bodies, needle-sharp teeth borne well forward in their sharp snouts, and long bushy tails. They are bloodthirsty hunters and do not hesitate to attack birds or beasts much larger than themselves. Although their victims occasionally



101 RED SQUIRREL, *SCIURUS VULGARIS*



102 GREY SQUIRREL, *SCIURUS CAROLINENSIS*



103 BADGER, PHOTOGRAPHED BY FLASHLIGHT AS HE LEAVES HIS "CASTLE"

104 A FAMILY OF HEDGEHOGS

include birds or eggs, they are mainly ground hunters, ranging the undergrowth for rats, mice and rabbits. Thus they are usually helpful both to farmer and forester, but gamekeepers are obliged to restrict their numbers to preserve ground-nesting game birds.

THE WEASEL (*Mustella nivalis* L.), a small dun-coloured creature, preys principally on rats and mice, and is commonest where such creatures abound. The larger STOAT (*Mustela erminea* L.), sixteen inches from nose-tip to tail-tip, is chestnut-brown above, white below. In the north of Britain, its colour changes to white throughout in winter, but this change occurs only partially, if at all, in the southern counties. Both these animals are abundant in and around our woods, but especially so near farms. The farmer's crops nourish the rodents on which they feed, whilst the woodland provides shelter for both weasels and their victims. They nest in holes in dry banks, and five or six young are born in each litter.

Two other members of the weasel tribe, being larger and more harmful both to game and occasionally to poultry, have been hunted down to the verge of extinction and survive only in the wildest regions. The POLECAT (*Mustela putorius* L.) measures two feet in length, and is prettily coloured in brown hairs over a yellow undercoat. It is closely related to the domesticated ferret. The PINE MARTEN (*Martes martes* L.), still rarer, is an elegant, slender animal, no less than thirty inches in total length, clad in handsome brown fur, with a white breast and belly. Essentially a woodland animal, it is an able climber and obtains a portion of its food above ground, in the form of birds, eggs, and possibly squirrels. It is able to leap from tree to tree, and to stalk its prey in cat-like fashion amongst the branches.

Brock, the BADGER, (*Meles meles* L.) (103), though technically a weasel, is quite unlike his relatives in build and habits. Grey in colour, apart from his black and white striped nose, this large stocky animal is common throughout the English woodlands. Emerging only by night from his enormous underground " castle," which he excavates by the use of his powerful claws, he is intensely wary, and therefore seldom seen. His diet is varied. Being too clumsy to hunt actively, he must rely on chance encounters to pick up flesh food, subsisting at other times on insects, nuts, and roots. A timid creature, he does next to no harm in the forest, but on occasion can make himself a nuisance by ripping up any rabbit-proof netting which crosses his old-established runs.

THE WILD CAT (*Felis sylvestris* Miller) is now confined to the Scottish Highlands. Its home is the woods and hilltops, it is a skilful climber, and its diet includes birds and rodents.

THE FOX OR TOD (*Vulpes vulpes* L.) may be found in most woodlands, particularly in those districts where it is preserved for hunting. A handsome, dog-like creature, in a red-brown fur coat with a bushy tail, Reynard varies his feeding and breeding habits, according to his habitat. The hill foxes of Wales and the Lake District bring forth their litters in rocky fastnesses, and hold their own despite constant hunting. But in lowland areas the numbers of foxes can be controlled by digging out and destroying the litters of cubs, or by hunting down the cubs at a later stage. In hunting districts the fox population is regulated to provide enough for sport, but not too many. Woodlands add to the variety of the chase, and enable the quarry to be found with comparative certainty.

The fox is a mixed blessing in the woods, for although his chief food is rabbits and similar harmful rodents, he also attacks useful birds and game, and sallies forth to attack poultry runs. But on balance and in reasonable numbers, he probably does as much good as harm.

DOMESTIC ANIMALS

Grazing and browsing animals are usually extremely harmful in the forest wherever they are protected by man, and especially so when confined by fences. They eat down the young trees and effectively prevent natural regeneration, whilst the trampling of their hooves damages the woodland soil by consolidating it. All such animals must therefore be excluded from the woods. They are always harmful, and in young plantations their presence is frequently disastrous. Animals on open range, however, do substantially less damage to young trees than do those which are confined to one area.

Goats, which roam the hills of North Wales, Galloway, and the West Highlands in a wild state, will even ascend low branches to strip them of bark. Sheep, with their close " bite," are very damaging, whilst horses are able to browse on young foliage to a still greater height. These are all alike creatures of the grassy plains or mountains, and their feeding habits, if unchecked or encouraged, ultimately reduce forest to grassland.

Less harmful are cattle and pigs, which are beasts of woodland origin with *splayed* hooves adapted to softer ground. Cattle browse to some extent on tree shoots, and devour tree seedlings in the course of their grazing. Pigs devour tree seeds of all the larger kinds, especially acorns. Neither, in small numbers, would prevent forest regeneration, but either will do serious harm when confined to feed in the woods.

Finally, there are two useful domestic animals which are of invaluable assistance to the forester in his endless war against the rabbit. The ferret will tackle the coneys underground, whilst the dog, be he spaniel, terrier, or lurcher, will hunt them in a variety of cunning ways on the surface.

EXTINCT ANIMALS

Any survey of the history of British woodlands must take into account the animals which have only recently been exterminated by man. For these were, in some sort, the unconscious protectors of the virgin forests, traces of which persist till this day. Most important was the WOLF (*Canis lupus* L.) which survived in Scotland until two hundred years ago (1743). Without the wolf, the wild deer, in the days before their numbers were restricted by that arch-hunter, man, would have increased in numbers until they threatened the very existence of the primæval forest.

Interesting, though less important, were the Brown Bear (*Ursus arctus* L.), exterminated in the eleventh century; and the cat-like lynx (*Felis lynx* L.), which probably roamed Britain down to the time of the Roman occupation. The beaver (*Castor fiber* L.) built his log dams across the Welsh rivers as late as the twelfth century. Wild cattle and wild swine, and probably wild ponies, were denizens of the British woods within historic times.

Nearly all British mammals are now controlled to some degree by mankind, in the conscious rôle of hunter or preserver. By recognising which are harmful to tree growth, and which others may be tolerated without damage ensuing to plantations, the forester can exercise this essential control without impairing one of the most attractive features of the countryside.

CHAPTER 12

BRITAIN'S FOREST HISTORY

Within historical times Britain has been converted from a land of forest, moor, and marsh, to its present general state of clearance, cultivation and drainage. This change was a slow one. During Roman times and throughout the middle ages, the woodlands dominated the British scene. British chieftains, Roman generals, Saxon thanes, and Norman nobles, all the pageantry of the past, lived and moved before a leafy background of oak, ash, or pine woods. Native forest products, timber, fuel, game and pasturage, were essential items in the rural economy of their times. This rich heritage they used with but little care for the future. Not until the days of Charles II did men realise that the forests were not inexhaustible, and that a conscious effort was required to maintain their fruitfulness.

This chapter deals with the native woodlands in their prime and the fading glory of their decline, before the logic of the seventeenth century had made our landowners tree-planters and architects of the forest scene. When forests grew naturally on every hand, few of the ancient chroniclers troubled to record the fact. The Normans, in their Domesday Book, written between 1081 and 1086, whilst diligently recording minute details of hamlets and cultivated lands, dismissed great tracts of woodland with the phrase " Hoc est vascata,"—this is waste. Nowadays such timber would be worth a king's ransom, but then it was valued only for the number of deer or swine which the woods would support.

Nevertheless, much can be gleaned from written records of the past. The limited extent of the tilled lands recorded in the Domesday Book betrays the existence of much wild country. Many forest laws were written down which show its importance to the countryside. The mute witness of surviving forests, now mere relics of their former extent, is supplemented by tree remains in peat bogs and certain coastal beaches. The microscopic examination of pollen from such deposits has revealed to botanists the range and importance of the various kinds of trees that comprised those ancient woodlands. Finally, the study of prehistoric man has given further evidence of the forests of the past. For example, the early Iron Age lake village of Glastonbury was built of timber, clearly in abundant supply, by craftsmen skilled in its working.

PREHISTORY

In early geological times, the surface of Britain was covered by a varied flora of primitive plants, which in some eras included the tropical species which formed the coal measures. Climate, soil, flora, and fauna, were alike different to those of the present day. The more recent forests date from the end of the Ice Ages, during which the earlier vegetation was almost exterminated by a long epoch of arctic climate. Certain trees since reintroduced, such as the sequoias of California, disappeared before that time.

Our present-day native flora was re-established by the spread of trees and plants from the continent of Europe. Some of these, such as the Norway spruce, had not reached us before the land-bridge linking Britain to the Continent had disappeared. They have since been brought across by man, who has constantly enriched the sparseness of our native flora, caused by accidents of geological and geographical isolation.

The Palæolithic men of the early Stone Ages returned with the forests. Their culture and tools were primitive, and they neither attempted agriculture nor pastured flocks. Living by hunting, fishing, and the gathering of wild fruits and roots, their influence on their forest home, which both sheltered and supported them, was slight.

But in the Neolithic or later Stone Age, and in the Bronze Age, which succeeded it, the dwellers in Britain became skilled in both agriculture and husbandry. Their tools and their skill in using them became equal to the task of cutting clearings for their crops. Their weapons enabled them to protect their flocks from wolves and other marauders. Instead of gathering all their food from the forest, they produced a portion on the cleared ground. They used timber for building, tools, and as fuel for smelting their metal and firing their pottery. Their primitive civilisation was largely dependent on the forest and its products.

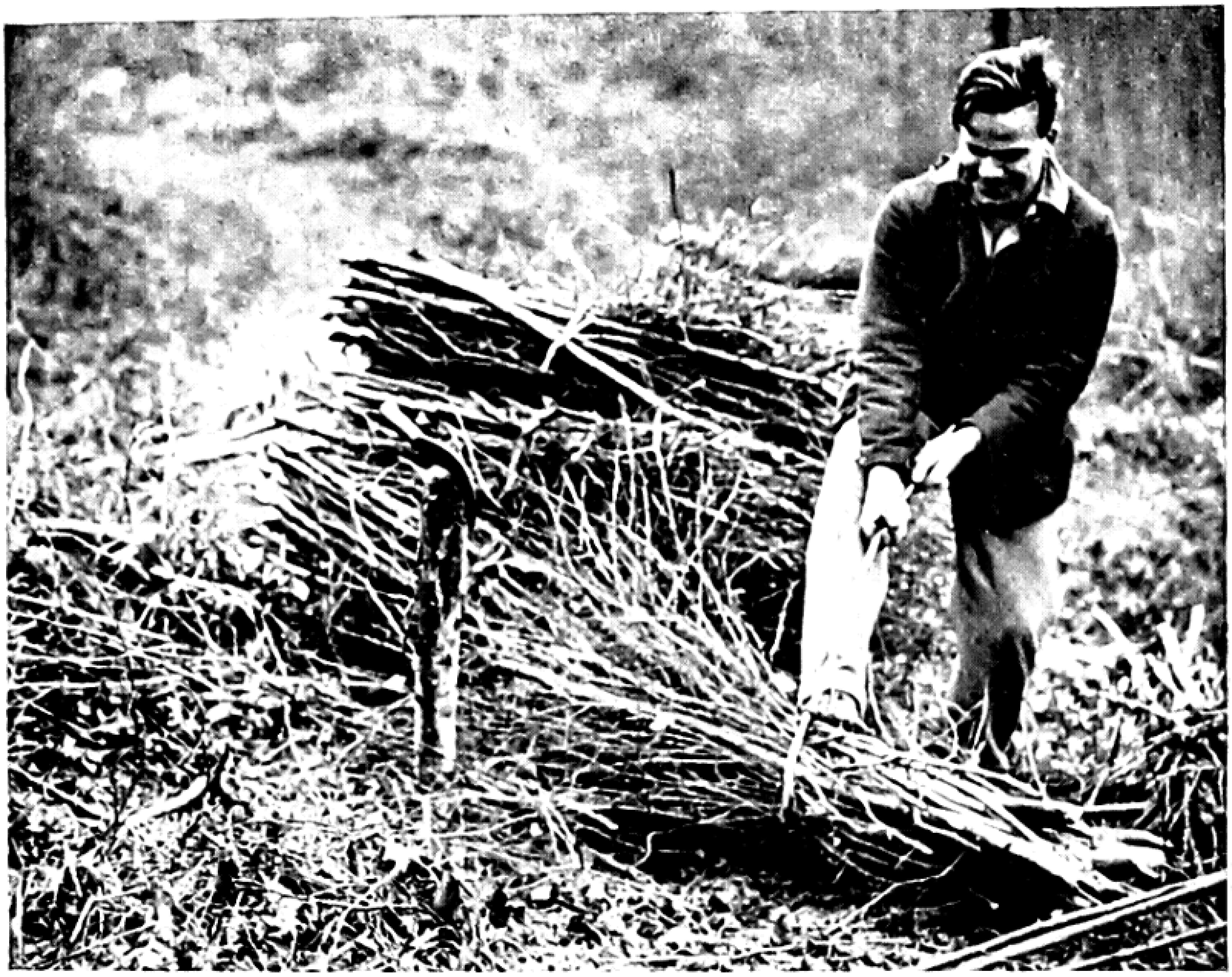
These Bronze Age people were succeeded as the dominant race in Britain by the Celtic Iron Age invaders from the Continent of Europe, who arrived about the year 600 B.C. Iron tools implied still greater mastery of the forest, and more skilful utilization of wood. Even so, most of these prehistoric people preferred to settle in the more open country. Their settlements, tumuli, monoliths, barrows, and forts, are found most frequently where it is reasonable to suppose the tree growth was sparsest, on hill tops, heaths, and dry downs.

ROMAN TIMES

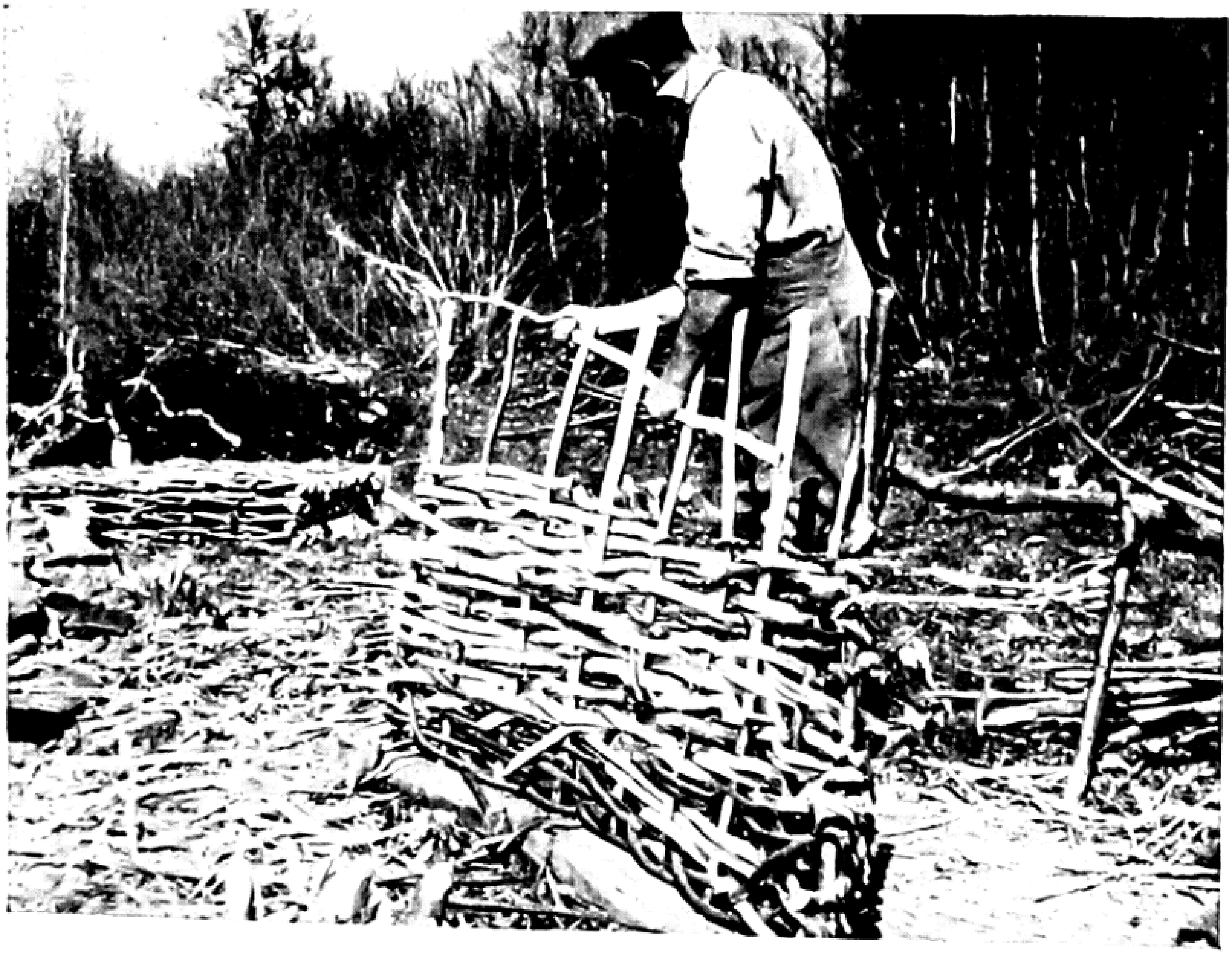
The written history of the British forests commences with Julius Caesar, who visited the country briefly in 55 B.C. He reported that it was largely covered with woodland, amidst which dwelt the Celtic tribes known collectively as Britons. During the four centuries of Roman rule which ensued over England and Wales, from 43 A.D. to 410 A.D., no very widespread clearance of the forests appears to have occurred. The Romans ran their great roads straight through the woodlands, from one fort or river crossing to another. Probably they maintained the straightness of their line by the use of smoke signals, which the surveyors could observe from the tops of the taller trees. This technique closely resembles the modern use of compass bearings to cut tracks through tropical jungles, and is indicative of closely wooded country.

WOODLANDS OF SAXON TIMES

The invasion of the Germanic tribes known as the Anglo-Saxons, which began about A.D. 410, resulted ultimately in widespread clearance of the woods which they found in Britain. The main cause of this was the increase in the density of the total population. This took effect even in the western districts to which the invaders did not penetrate, as those Celts who fled before them had to share limited land areas with their original inhabitants. The additional land required for agriculture could only be obtained at the expense of the forests. Further, the newcomers preferred to establish their villages in the lowland valleys, in much the same sites as they occupy to-day. They were

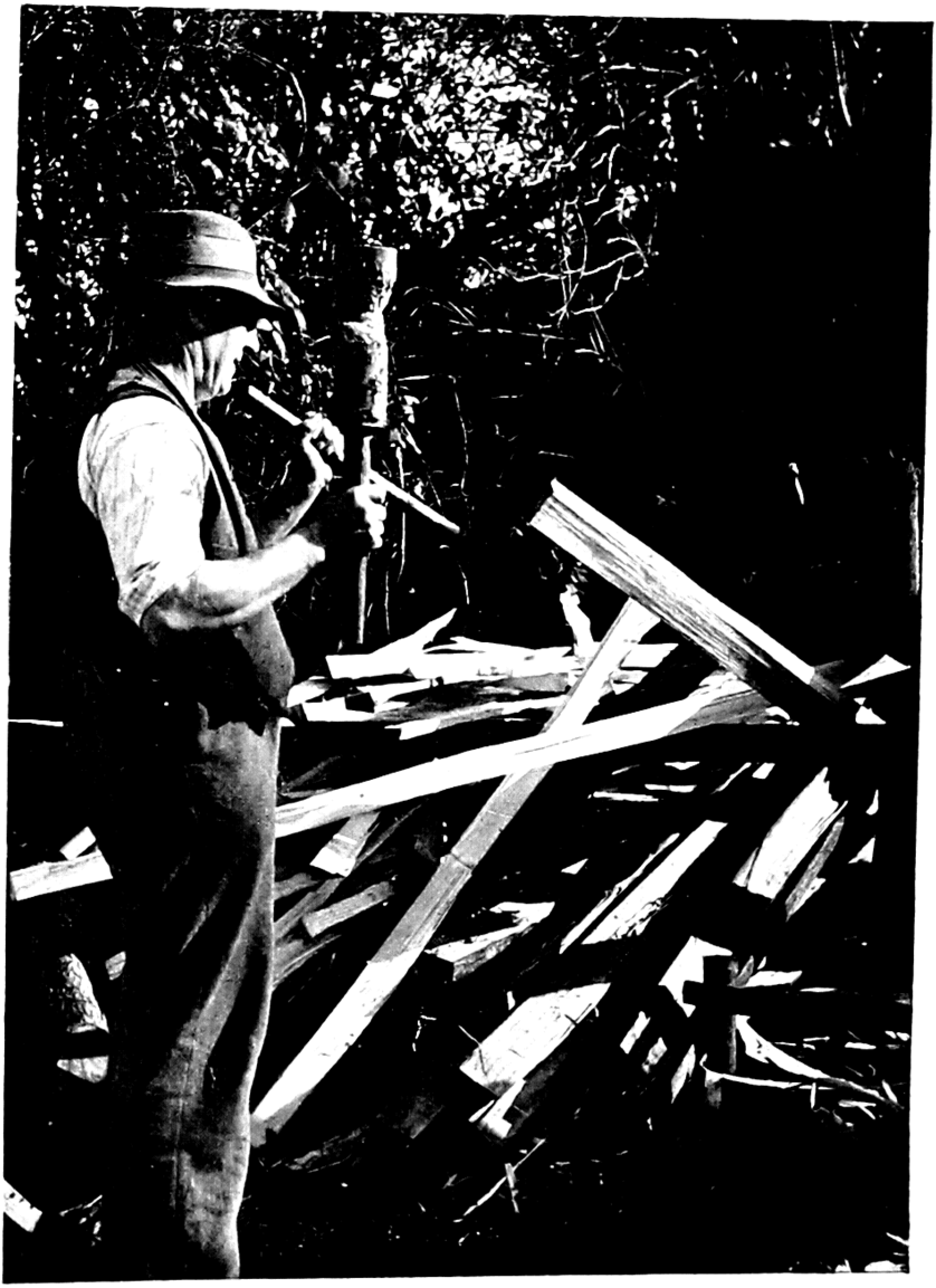


105 BINDING FAGGOTS WITH A HAZEL WITHE



106 WEAVING HAZEL RODS TO FORM A WATTLE HURDLE

ANCIENT CRAFTS THAT CONTINUE UNCHANGED



107 CLEAVING HURDLE BARS FROM ASH, USING A FROE AND A BEETLE

not deterred by the high woods, and many place-names of Anglo-Saxon origin perpetuate the memory of ancient oaks, beeches, and ash trees.

This closer settlement gave the woods a scarcity value for the first time. Timber itself was still plentiful, but other products, such as game and acorns for feeding swine, began to be in short supply. This led to the passing of England's first forest laws, by Ine, King of Wessex, in A.D. 693. It is surprising to find the origins of our forest law at so early a date. The overlordship of forest areas had now become a matter of importance. Already, long before Norman times, the thanes, earls, and the king himself, had each claimed their privileged hunting grounds. The former boundless wilderness had been split up by advancing settlement and cultivation, and distinct forests, each with defined boundaries, called *metes*, *meres*, or *marches*, were now recognized.

In the Welsh Marches, the construction of the great earthwork known as Offa's Dyke, about the eighth century, provides evidence of woodland persisting in that wild borderland of hills and rivers. For it marked the dividing line between the Welsh and the English forests, as hunting or grazing ground. In open country, a row of cairns would have sufficed, but amidst the trees a continuous embankment, which could not be overlooked, proved a surer means of avoiding endless boundary disputes.

The later Danish invasions increased the density of population still further, for the first period of pillage was followed by considerable settlement in the north and east of England, north-east Scotland, and elsewhere. Documentary evidence of the continued importance of the forests is afforded by King Canute's Forest Laws, promulgated at Winchester in 1016. The version of these laws that has survived is manifestly imperfect, including interpolations of a later date, yet it is evident that Canute did turn his attention as a lawgiver to the question of the forests, if only to reaffirm the existing English practice and customs.

THE FOREST LAWS OF THE NORMANS

With the Norman Conquest of 1066 the royal forests of the Saxon kings were transferred to an alien ruling race. As is the wont of conquerors, the newcomers enacted fresh laws and administered them harshly. Resentment against the foreign overlords found a rallying point in defiance at one of the few points where the weak could fight the strong—out in the wildwood.

The Normans valued the woodlands for hunting, which in those days meant not only sport but food and a training in warlike skill. They were obliged to concede the rights of their Saxon subjects to use other forest products, such as fuelwood, the " pannage " of acorns and beech mast for pigs, turf for fires, marl, and gravel from the forest soil, bracken and leaf litter, and, in many forests, the pasturage of sheep and cattle.

The full stringency of the forest laws applied only to the royal forests, which were, however, widespread and extensive. As a rule, the survival of the name " forest " on the map of England, indicates a former royal hunting ground of Norman times, for as such the word came to acquire a particular legal significance. Lesser nobles had their " chases," " warrens," and enclosed " parks," and doubtless strove to enforce therein the code of laws which their sovereigns had devised for their own personal domains.

After the chief royal forests had been defined, mainly on the sites of older Saxon hunting grounds, William the Conqueror cast covetous eyes upon a wild tract of south-west Hampshire. This, in 1079, he added to his private *desmesne* under the title which it has borne ever since—the " New Forest." It was then a thinly wooded stretch of infertile soil, and the story of villagers being dispossessed and driven from their homes has been greatly exaggerated by prejudiced chroniclers of a later age. What few villages there were still survive, with Saxon names and in one case a Saxon church. But here, as elsewhere, the enforcement of the severe forest laws, which prescribed the death penalty for the killing of the king's deer, was bitterly resented. Three of William's descendants met with violent deaths, all alike under suspicious circumstances, within the bounds of this one forest. The most famous victim was King William II, surnamed Rufus, slain by an arrow near Malwood in the year 1100.

At this time the beasts of the chase included wild boar, wolf, and bear. Falconry was a favourite sport of the nobles. Besides providing sport for their monarchs, the royal huntsmen had to keep their tables supplied with game at all seasons. Their quarry included birds now scarce or extinct in southern England, such as blackcock and bustard. The wealth of food to be gleaned from the woods and waste lands attracted both solitary poachers and more dangerous outlaws, such as the band of the legendary Robin Hood, who ensured that the forester's office was no mere sinecure. Clad in their coats of Lincoln green, at once a badge of office and a form of camouflage, the Norman foresters and woodwards had to be ready to tackle wild beast or human desperado, oft times alone in the depths of the far woods. But the free life of the open air attracted the hardiest, boldest and ablest retainers of kings and noblemen, who became skilful with spear and longbow, and in the training of horse and hound. Men such as these formed the backbone of the feudal forces which marched beneath the royal standard to the victories of Crécy and Agincourt.

The legal enforcement of the forest laws lay in the hands of special courts and officers. Separate courts were needed since so many of the offences were against the Crown, and the laws themselves so intricate that they required the interpretation of experts. Three degrees of forest courts were recognized. Two of these, the courts of Attachment and of Swainmote, were local to each forest, and met at frequent intervals to deal with minor offences. Those suspected of major crimes were committed to the " Justice Seat in Eyre " (French: *Ire*, to go) a perambulating court which visited each forest in turn at intervals of two to three years. There were two circuits in England, each with its Chief Justice, one to the north of the river Trent, and one to the southward.

The principal officers of the lower courts were termed " Verderers " (French *vert*, signifying green pasture). These were appointed from amongst the local knights and barons, and had the general functions of Justices of the Peace. They were assisted by " Regarders " (French: *Regarder*, to overlook), always twelve in number, who acted after the fashion of a jury, but who had also to patrol the forest boundaries every three years and accept responsibility for the forester's conduct.

Actual administration of the forest lay in the hands of a Lord Warden, appointed and responsible to the king, who had to act as prosecutor and " present " offenders who had been " attached " or arrested, before the courts. But in practice the work of policing the forests lay with foresters or rangers appointed by the Lord Warden. These foresters lived partly by their office, which usually enabled them to exact dues in cash or kind from commoners who pastured stock or enjoyed other forest rights, and partly by farming lands which they held as further pecuniary reward.

Forest offences included poaching, hunting, and even the keeping of hounds within the forest bounds. There were penalties prescribed for abuse of common rights, and for encroachments on the forest land which were curiously frequent. On the whole, it was better to steal the forest land than to steal the deer. The humble poacher might lose his head, but the bold landowner who enclosed a strip of forest could often compound his offence with a small fine and an agreement to pay quit-rent. Even a smallholder might claim his squatter's right to a piece of ground by maintaining his home, complete with hearthstone, on an enclosure for a stipulated period. It is not surprising to find that the area of forest land showed a continuous decline. Obviously, much of this trespass must have been "arranged." Much as they loved the chase, the feudal overlords measured their power in terms of fighting men. If, by closing one eye to the cultivation of the wilderness, they could raise a few more loyal henchmen, why quibble over the letter of the law?

In this complex of hunting, pasturage, and land use, combined with feudal rights and duties far removed from modern ideas, the woodlands of the open lands received scant attention. Foresters were enjoined to maintain cover for deer, and to protect grown timber from theft, but no heed was paid to the younger trees, which were eaten in their early stages by deer or domestic animals, or cut for poles and firewood a few years later. The nobles' demand for venison, and the commoners' call for pasturage, combined to prevent the renewal of the older trees by natural regrowth. This was most marked in the hill lands where sheep were kept, for these animals bite the herbage so closely that few seedling trees survive. In course of time the deer became less important, but the common rights remained, and most of our modern commons are vestiges of former forests.

It would be tedious to recite the many changes in forest laws which were wrought by various medieval monarchs. That forest policy was a major factor in politics is shown by the following list of Acts of Parliament: Henry I; Henry II, *Assize of Woodstock*, 1184; John, *Magna Carta*, 1215; Henry III, *Charta de Foresta*, 1217 & 1223; Edward I, *Assiza et Consuetudines Forestae*, c. 1278, *Ordinatio Forestae*, 1306; Edward III, *Charter of Confirmation*, 1327; Richard III, 1383; Henry VII, 1485; Henry VIII, 1539; and Edward VI, c. 1550. These enactments reflected the strength, or weakness, of the reigning monarch on a thorny point of issue between sovereign and subject. The last king to stand out for his rights was Charles I, who added fuel to the fires of rebellion by reviving the moribund Courts of Eyre in 1635. After his deposition there was a token revival by Charles II in 1669, but thereafter the whole elaborate system of special courts, laws, and privileges, faded into obscurity. Its ablest chronicler was Manwood, whose " Forest Laws," first published in 1598, is the best first-hand account of a forgotten phase in the development of the English countryside.

MEDIEVAL FORESTS OF WALES, SCOTLAND, AND IRELAND

The full force of the Norman forest laws applied only to England, for the rest of the British Isles was independent at the time of their enactment. Although large areas of the Celtic lands were never tree-clad, being mountain, moor, or bog, their present treeless state is the result of changes in land use throughout the centuries.

In Wales and Scotland, so long as cattle were the mainstay of farming, the trees persisted in the vales and glens. But the increase in the importance of sheep, which bite the herbage close and so destroy tree seedlings, changed the character of the valleys, slowly but surely, to grassland.

In Ireland, the native forests were limited in tree species and seldom of the best growth. Exposure to western winds, high rainfall, combined with impeded drainage, kept the trees in check. This marginal type of woodland is readily destroyed by grazing, which favours the growth of grasses in that favourable climate, but checks or destroys struggling seedling trees. In places, too, spreading peat bogs encroached upon the forests. So the native Irish woodlands, famed in the tales of the Kings, dwindled to scattered remnants.

TIMBER IN MEDIEVAL FORESTS

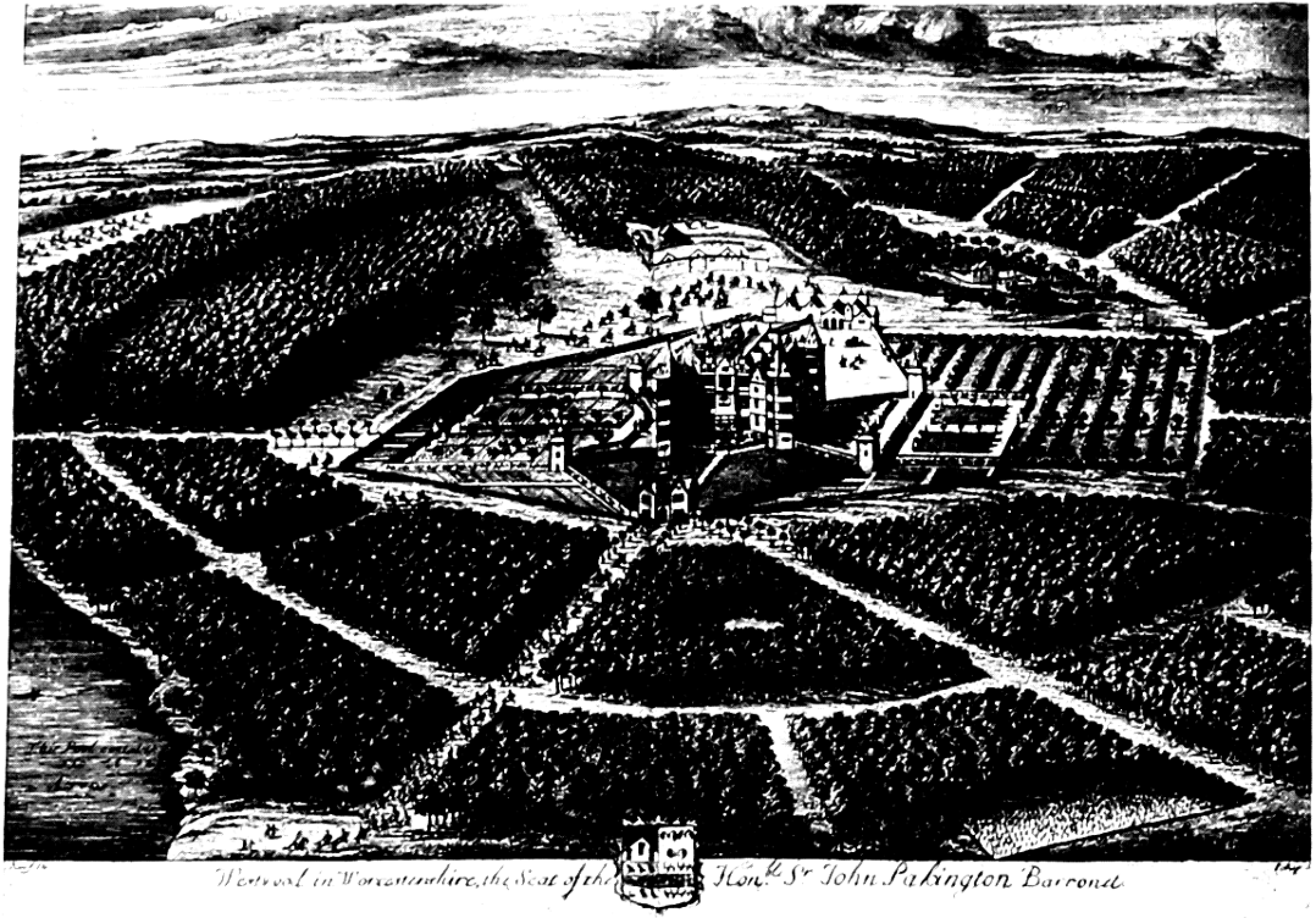
The chief fault of the Norman and earlier forest laws was that they concerned themselves closely with the rights of hunters and farmers, but neglected the preservation of young trees which might have grown to timber. As time went by, grown timber acquired a value, from its growing scarcity, due not so much to increasing use as to lack of replenishment. Young trees, being unprotected, were cut by the thousand for firewood, fence poles, or building material; still smaller ones were wiped out by grazing sheep or browsing deer. The tall trees lost their children, and their race was doomed.

Yet throughout their decline, these virgin English forests contributed to the rise of the country's sea power, and the advance of its civilisation. They were the sources of the sinews of war, ships and iron. The earliest legal recognition of timber came in an act of that wise monarch Edward I, in 1306. He reserved all the oaks in the royal forests for the use of the Crown. Before that, apparently, they had been cut at will by all comers.

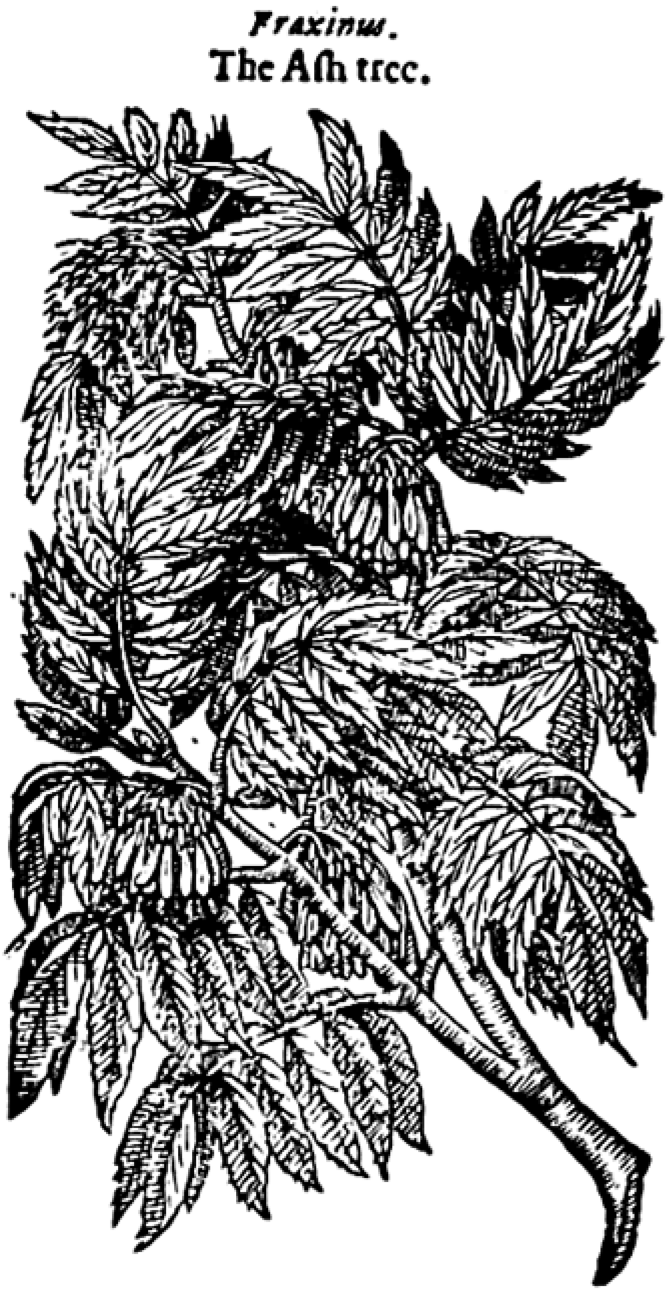
As foreign trade expanded, more and more fine oak was used for shipbuilding. The chief sources in the south were the Forest of Dean, the New Forest, and Bere Forest in Hampshire, all of which lay near good harbours and shipyards. By 1587, Drake had sailed his " Golden Hind," a tiny wooden ship, British built and doubtless of native timber, around the world. The English shipyards were a coveted objective of Philip of Spain's great Armada ten years later, and the toughness of the craft that opposed it had a share in the defeat of that proud fleet.

Already Elizabeth, alive to the danger of a depleted store of ship timber, had passed in 1558 an " Act that Timber shall not be Felled to make Coals for the burning of Iron." For the iron foundries, dependent on charcoal before the mining of mineral coal had developed, were making grave inroads into the forests. This was most marked in the iron ore districts, the Sussex Weald, Cumberland, and North Yorkshire. Charcoal, too, sustained the early house fires and smithies of London. Elizabeth's act had but limited effect, and charcoal burning continued.

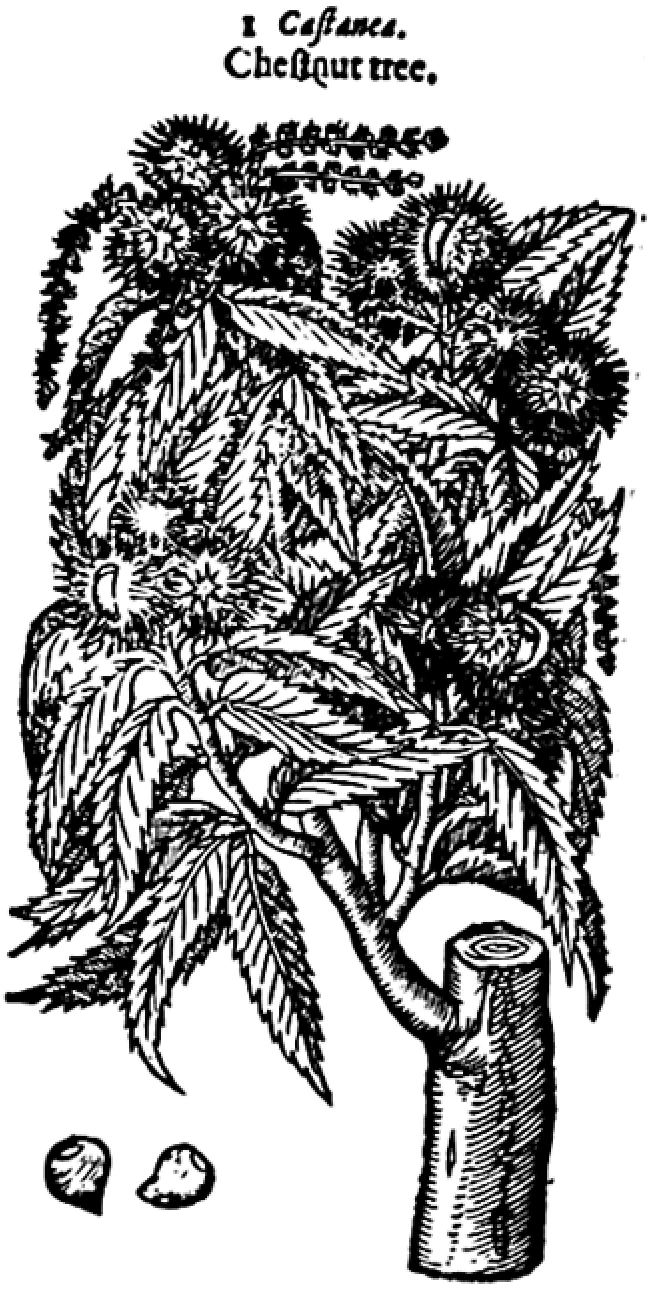
At length the overcutting of the old trees, and the damage to the young ones caused by the exercise of forest rights, led to the introduction of purposeful forest planting as detailed in the next chapter. Little or nothing was preserved of the old natural woods, of which only fading relics remain. Unlike continental forestry, which began with the preservation of existing woods, modern


Westwood in Worcestershire, the Seat of the Hon.ble Sr John Pakington Baronet

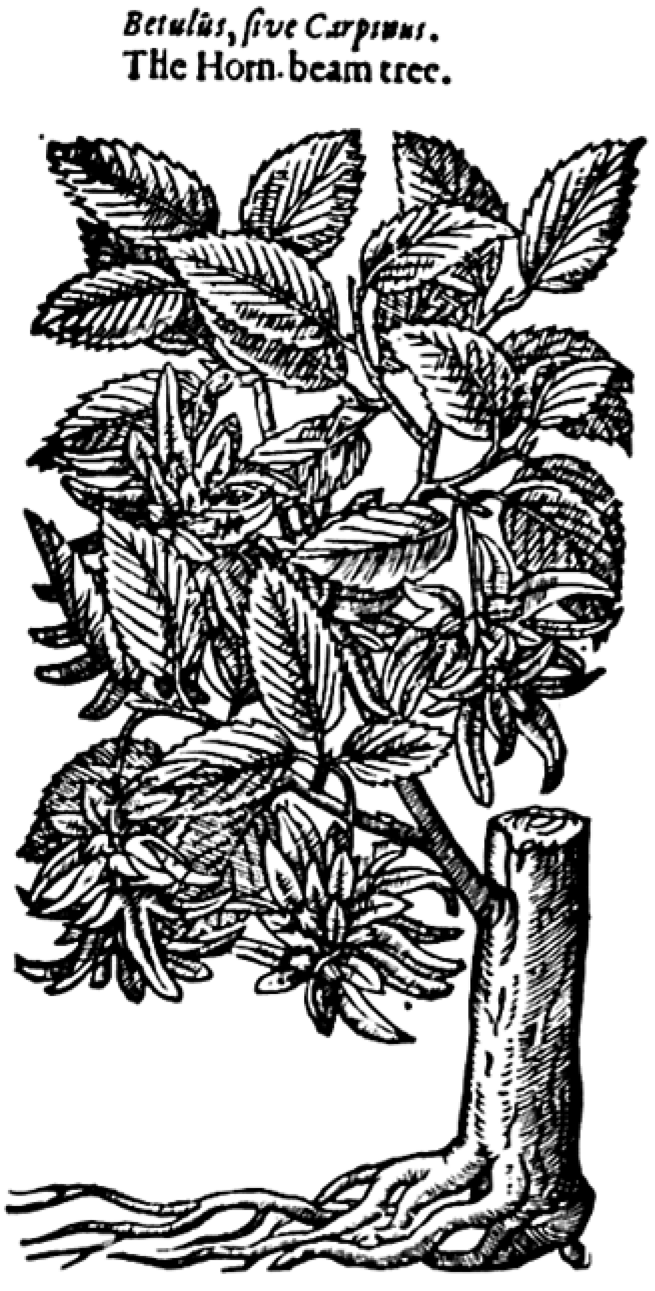
108 WESTWOOD IN WORCESTERSHIRE, ENGRAVED BY KIP, *CIRCA* 1720. NOTE THE HUNTSMEN, THE DEER IN THE UPPER LEFT-HAND CORNER, AND A PLANTATION OF YOUNG TREES IN THE RIGHT FOREGROUND



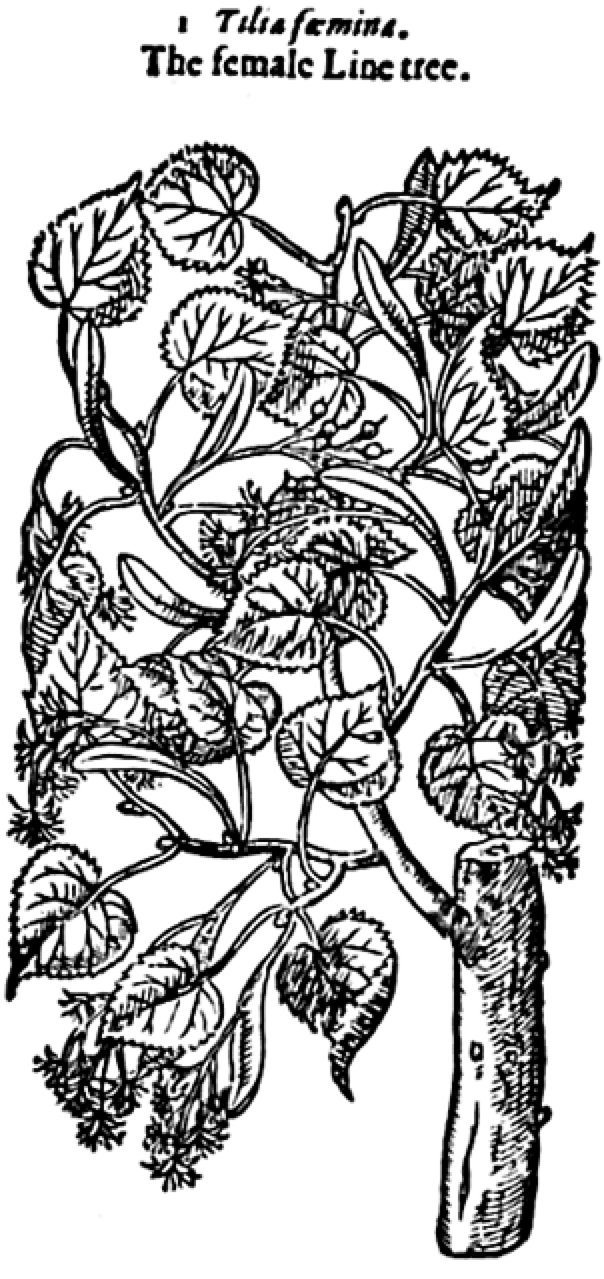
109 ASH


1 Caſtanea.
Cheſtnut tree.

110 SWEET CHESTNUT


Betulus, ſive Carpinus.
The Horn-beam tree.

111 HORNBEAM


1 Tilia fœmina.
The female Line tree.

112 LIME

QUAINT YET ACCURATE DRAWINGS FROM GERARD'S "*HERBALL*," *1597*

British forestry began with the establishment of trees upon bare lands. This accounts for the fundamental differences in outlook and methods.

THE HISTORY OF WOODLAND WORDS

A curious sidelight on the extent to which our forefathers were acquainted with their forests, is afforded by the origins of everyday words for trees, tools, and other features of woodland life. The Anglo-Saxons were familiar, in their former homelands, with all the trees which they found in Britain. Therefore, Germanic names replaced the Celtic ones for every English tree except the yew. The woodman's tools, and the items of his daily work, are still known by Anglo-Saxon names which closely resemble their modern German counterparts, as *axt* for axe.

Celtic speech survives chiefly in place names derived from natural features. A frequent example is the word " sheet " or " shoot," an Anglicization of the Welsh *coed*, which denotes woodland on many English maps, as at " Chute Forest " in Wiltshire. By contrast, the language of the chase, and of legal matters concerned with the old forests, was Norman French, interspersed with the dog-Latin of the medieval clerks.

CHAPTER 13

FORESTRY IN MODERN TIMES

In southern England the development of systematic forestry proceeded in three well-defined stages, each marked by its own method of growing trees. First came the Coppice system, devised to produce the small poles which were becoming scarce in the open natural forests, owing to overcutting and overgrazing. This dates back to the fifteenth century, and was succeeded a century later by the Coppice-with-Standards system, which secured a limited supply of larger timber from the coppice areas. In the seventeenth century, under the influence of increasing demands for large timber as the natural forests were worked out, English foresters developed the High Forest or Plantation system, which continues in favour to the present day.

The coppices were only of minor importance in the north of England, Scotland, Wales, and Ireland; and although important historically they are of little significance in present-day afforestation and replanting. The main trend of modern British forestry dates from the Restoration of the Monarchy in 1660. By then, the rule of the Commonwealth had swept away the power of the old forest laws, and the landowning classes, who until very recent times have been the most active tree planters of the country, felt that they could safely make a long term investment on their estates. This movement was stimulated by the publication, in 1662, of the classic work " Silva, or a Discourse of Forest Trees, and the Propagation of Timber in His Majesty's Dominions," by John Evelyn, known to history and literature as a statesman and diarist. Delivered firstly as an address to the newly-founded Royal Society, this book firmly established and publicised the main principles of planting and tending woods and forests on the High Forest system. Evelyn's aim was the production of big timber, chiefly oak for naval shipbuilding, the shortage of which had been revealed by the Dutch wars. Nine editions of his book, with footnotes and illustrations accumulating as time progressed, had appeared by 1812.

Evelyn was also a noted gardener, and it is probable that the true roots of English forestry lie deep in the sister craft of gardening. It is a short step from the orchards of medieval castles and monasteries to the first enclosed coppices that marked the beginning of the science of timber production. The earliest recorded book dealing with the cultivation of trees in the English language, is John Fitzherbert's " Book of Husbandry," which appeared in 1523, during the reign of Henry VIII. Trees received attention in the early Herbals of Gerard (1597) (109-115) and Parkinson (1629), whilst in 1613 there appeared the first English work dealing entirely with forestry, quaintly entitled: " New Directions of Experience for the Increasing of Timber and Firewood," by Arthur Standish.

COPPICES

In coppice woodland, which still commonly persists in southern England, the trees are cut back at regular intervals, and only small produce is obtained. They can be formed in natural woodland, by cutting back immature trees, but appear to have been specially planted on fertile enclosed areas in Tudor times. At that date coppices were far more profitable than they are to-day. Their name is derived from the French *couper*, to cut, and wherever the name "copse" or " coppice " appears on the map, it may be assumed that the woodland was at one time treated in this way (116).

Evidence of the value of coppices in former times is afforded by the high tithes which some of them still bear. Others are charged with the furnishing of considerable incomes to endowed charities such as almshouses, whilst in 1664 Charles II bestowed the revenue from three coppices in the New Forest on one of the ladies of his court. The utilisation of coppice growth depends on the skilled labour of hurdle-makers, cleavers, wood-turners, and bark-strippers, and is aided by a market for faggots and firewood. In a few districts it continues to pay, but one of the main tasks now confronting English foresters is the conversion of worn-out coppice to profitable High Forest.

These coppices are easily identified by the fact that several trunks or stems rise from a single root. The trunks are in consequence mis-shapen, and first-class timber can never be grown in this way. Coppice provides good cover for game, but it is difficult and costly to eradicate when no longer required. The earliest legal recognition of coppices occured in the reign of Edward IV. In 1482 he passed an " Act for inclosing of woods in forests, chases, and purlieus," which permitted landowners to fence in such woods for a limited period of years to exclude grazing animals whilst the trees were newly-planted or recently cut over. In 1924 the total area of coppice and the allied coppice-with-standards was estimated at 500,000 acres. They comprised nearly 20% of our total woodlands.

COPPICE WITH STANDARDS

This method, also common in southern England, consists in allowing isolated timber trees to grow to their full height as " standards " amongst the coppice. Oak and ash are the species most commonly grown in this fashion. The standard trees are obtained by preserving young oak or ash poles, known as " stores, standels, or tellers," amongst the coppice whenever it is cut. This provides a constant recruitment of immature trees to replace the maturing standards which are cut down as required. In theory, the mature timber is cut at regular intervals, called the " standard rotation," of about 100 years; whilst the coppice is felled at fractional periods, e.g. every ten years. But in actual practice such regularity is rare.

The great drawback of this system is that no competition exists between the widely spaced standard trees, which often number only a score or so to the acre. Consequently they produce wide-spreading crowns and short trunks, giving a poor return of useful timber for the large area of ground which each tree occupies. At the same time the coppice growth beneath them is depressed. So the system is now regarded by modern foresters as uneconomic and obsolete, though large areas still persist in more or less derelict and neglected condition. At its outset, this method of forestry was stimulated by Henry VIII, who in 1543 passed an " Act for the preservation of Woods," which insisted on the retention of at least 12 standards per acre whenever coppice was cut. But owners were permitted to fell mature standards when large timber was needed for some definite purpose; the act aimed at the preservation of young potential timber stems.

HIGH FOREST

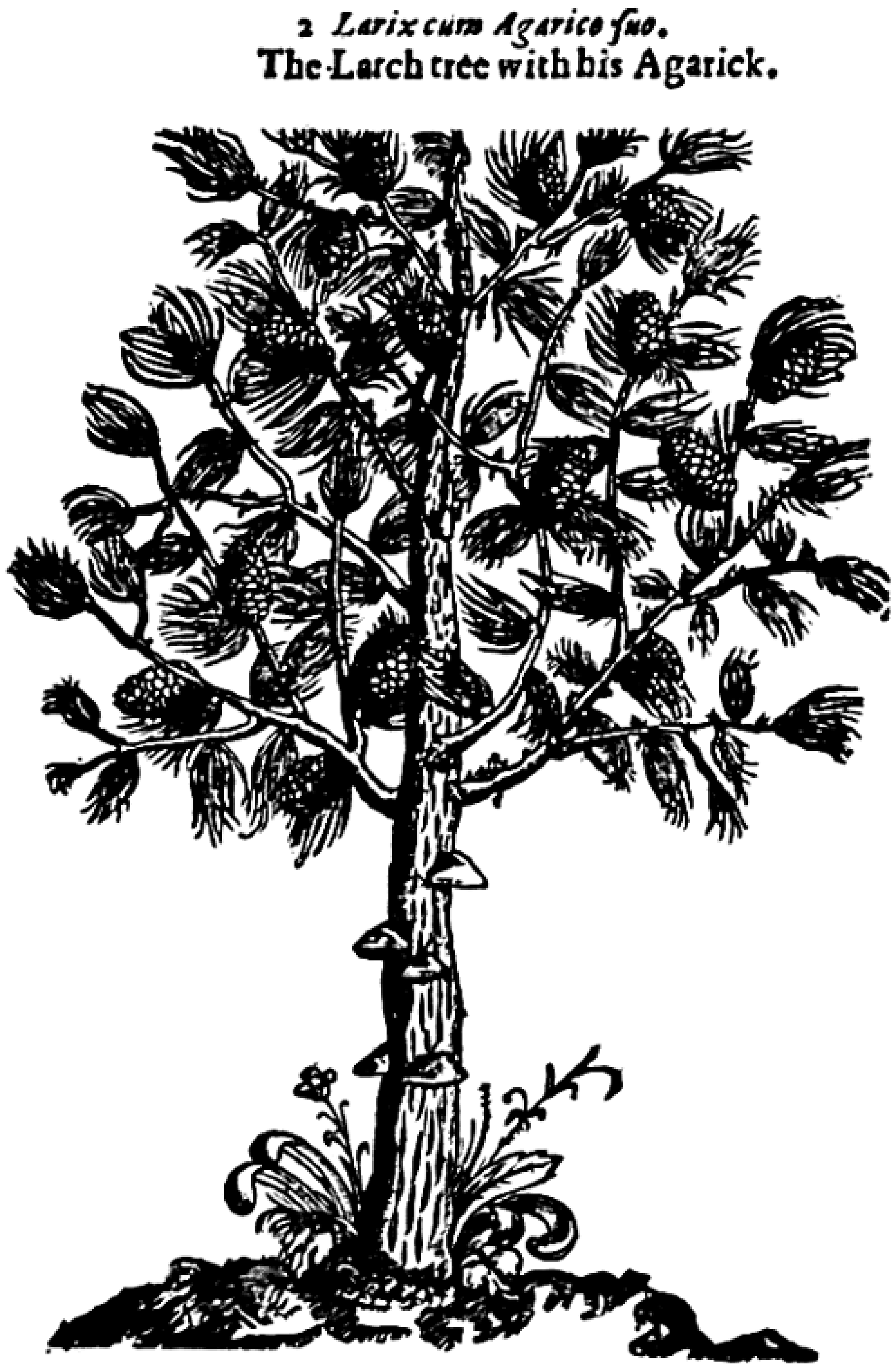
The cut-back coppices and their low standard trees are important historically because they show how the problem of raising timber was first tackled in England. As one goes north they become less frequent, until in Scotland the new plantations are almost invariably " High Forest." Instead of being cut back at intervals of a few years, all the trees are allowed to grow upwards; many are removed at intervals in " thinnings," but the woods are kept so dense that coppice shoots, if they appear, are suppressed. Conifers, which do not throw up coppice shoots, can only be grown as High Forest.

High Forest planting aims at reproducing the tall timber of the wildwood, by establishing, in one way or another, a large number of young trees which grow in competition amongst themselves. So they draw one another up to their full stature, at the same time, creating true forest conditions of soil, flora, and fauna. When such woods are formed by the hand of man, either by sowing seed or planting young trees, they are technically known as " artificially regenerated." If they are formed by natural seeding without man's direct assistance, they are termed " naturally regenerated "; such natural woods are rare in Britain.

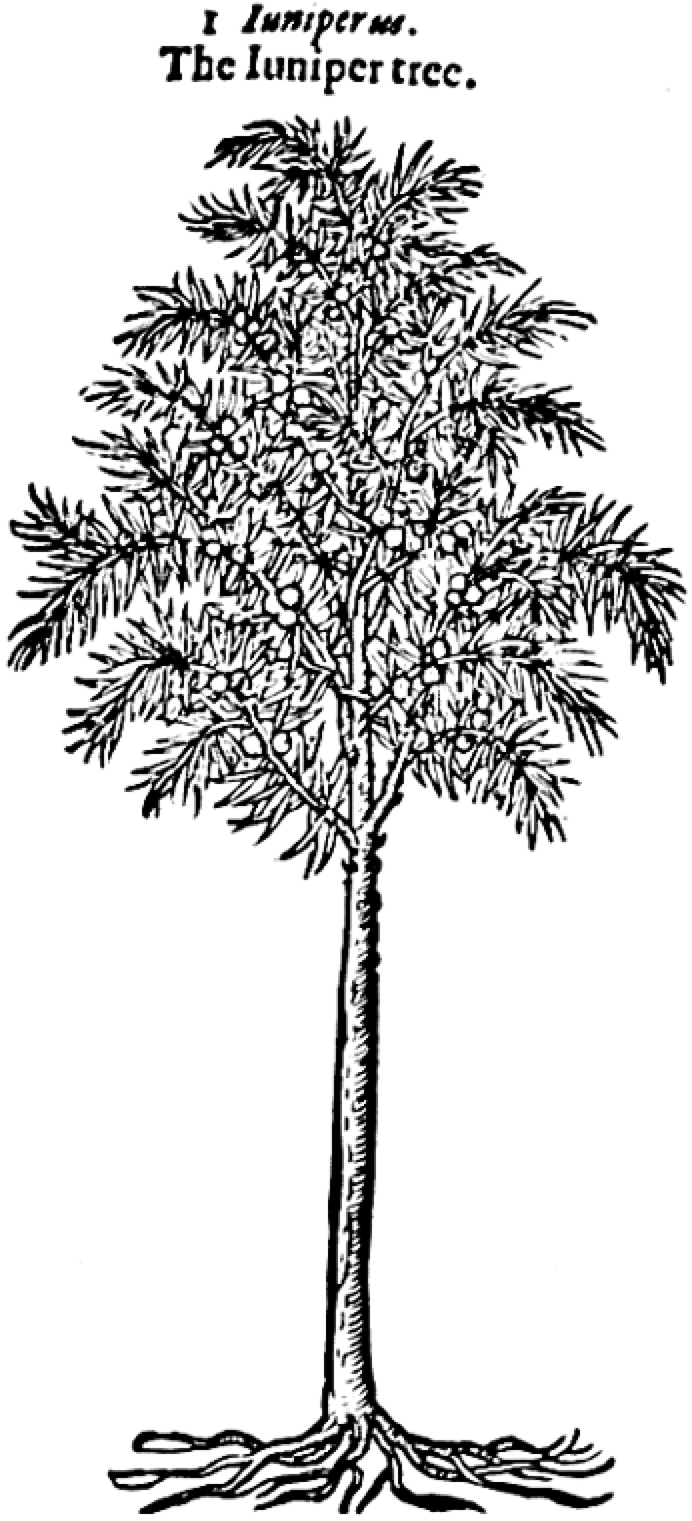
When the young trees are all established in the same year, apart from a few which may be added later to replace failures, the crop is called " even-aged." In this respect it contrasts sharply with natural virgin forests, which contain a proportion of trees of all ages, and are consequently designated " uneven-aged." The typical Scottish or modern English plantation is therefore an example of " even-aged, artificially regenerated, High Forest." Although this method is so familiar to our foresters, it is only one of several systems of growing timber, and in fact the bulk of the world's timber is still grown in other ways.

Under this method, the plantation is established by planting (or sowing) a large number of trees evenly spaced out at intervals of some five feet apart, requiring about 1,750 to each acre of ground As the trees grow, their numbers are gradually reduced. At first, disease, insects, animal damage, or abnormal weather conditions, take their toll, supplemented by the losses which occur in transplanting. Later, when the trees have grown some twenty to thirty feet tall, and their branches have met overhead, the forester steps in to carry out *thinnings.* This operation is essential to the success of an even-aged plantation, for it replaces the gradual elimination of unsuccessful trees which occurs in the uneven-aged wildwood. By skilfully removing a portion of the young trees, scattered throughout his crop, the forester maintains the growth and mutual competition of the remainder. By gradual stages, the number of surviving trees is cut to a fraction, perhaps one-tenth, of the number originally planted. At length, this " final crop " is adjudged " mature." This means that they have reached an age, probably between 60 and 150 years, when further improvement in the volume or quality of the timber cannot be expected. Then comes the " final felling," in which the surviving trees are cut down. Then the whole process begins again.

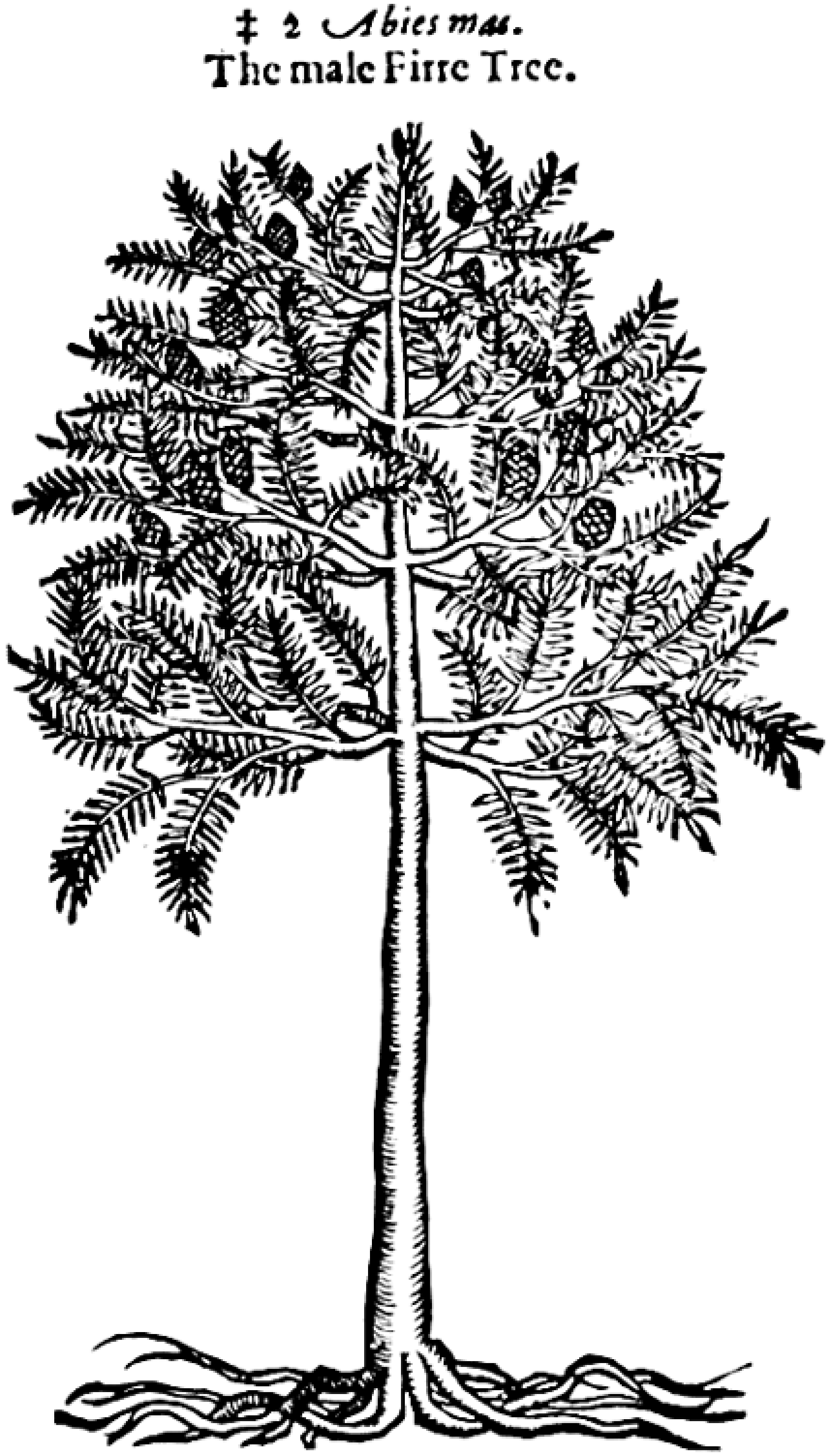
The interval between the first planting and the final felling of the tree crop is called the " rotation." Although there is a long wait for the final timber crop of each rotation, the yield of poles and smaller timber from thinnings


2 *Larix cum Agarico ſuo.*
The Larch tree with his Agarick.

113 EUROPEAN LARCH, ATTACKED BY A FUNGUS, *POLYPORUS SULFUREUS*

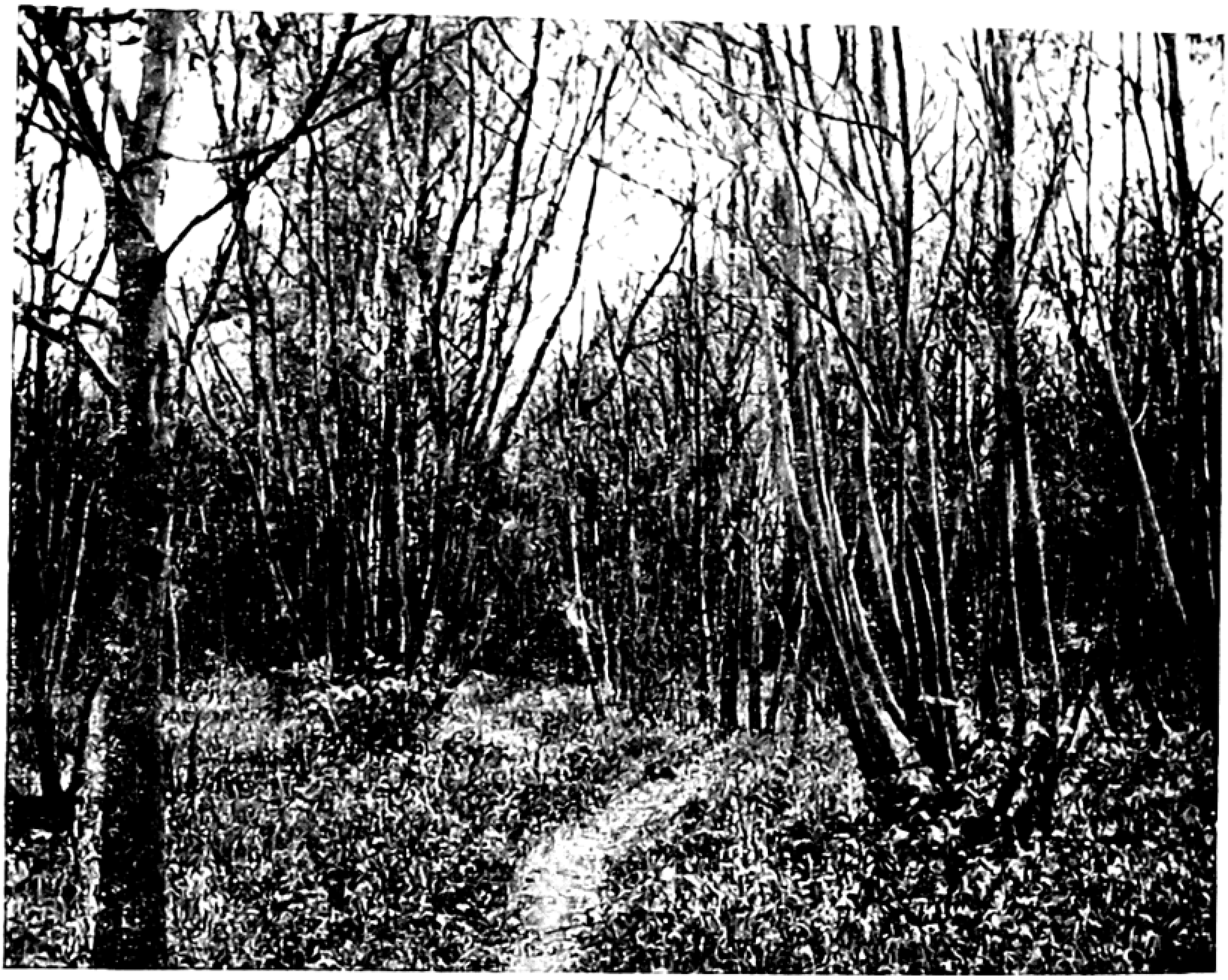

1 *Iuniperus.*
The Iuniper tree.

114 JUNIPER

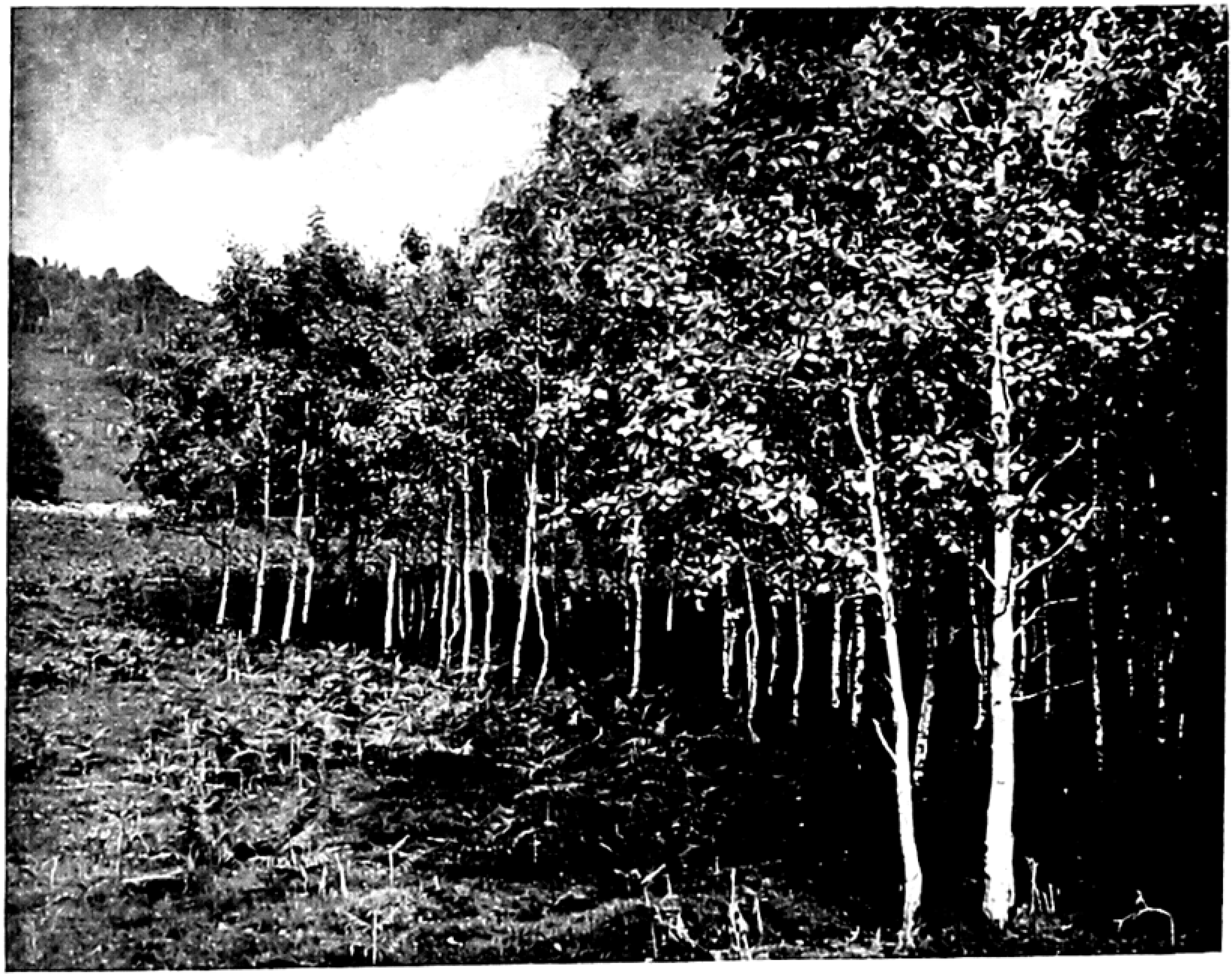

‡ 2 *Abies mas.*
The male Firre Tree.

115 EUROPEAN SILVER FIR

GERARD'S SKETCHES OF CONIFERS, RECORDING AN EARLY KNOWLEDGE OF FOREIGN KINDS



116 SWEET CHESTNUT COPPICE AT ADDINGTON, SURREY



117 SUCKER SHOOTS OF ASPEN IN GLEN FESHIE, INVERNESS

begins to come in at an early age, and adds greatly to the returns in terms of produce and money.

NURSING. Under the right conditions, almost any tree may be grown as pure High Forest. But on difficult sites certain kinds, known collectively as "successor" species, are difficult to establish without the help of hardier "pioneer" trees. This kind of protection of one tree by another is termed "nursing," and is often achieved by *interplanting*. An example is the use of Scots pine to protect spruces from frost and exposure in the early stages of a mixed plantation; as the spruces become established, the pines are gradually removed.

UNDERPLANTING. It is sometimes possible and desirable to grow a second crop of trees *underneath* the first (168). For example, when an oak crop has reached an age of 60 years or more, young beeches may be planted beneath it, as they increase the fertility of the soil and so benefit the oak as it matures. This may result eventually in *Two-storeyed* High Forest, forming an understorey of beech beneath an overstorey of oak. In time the oak may be removed, leaving a pure beech wood. Only shade-bearing trees can be used for underplanting.

MIXTURES. High Forest may be "pure," that is, of one kind of tree only, or "mixed." Mixtures are formed by the interplanting of two or more different kinds. Usually their composition is a simple matter of alternating rows of two species; but the patterns and proportions may be infinitely varied. Apart from the special cases of nursing and underplanting discussed above, mixtures are not in great favour with present-day foresters. No two species of tree are likely to grow on the same ground at the same speed or in the same fashion. Therefore the management of mixtures calls for the continual exercise of high technical skill by the foresters in charge of them. Properly managed, they provide a useful variety of produce and the total yield may be high, as each tree uses the ground in its own way.

In 1924, High Forest woodland was found to occupy 1,400,000 acres throughout Great Britain, comprising nearly 50 per cent. of the total woodland area. It is by far the most important type of woodland, and subsequent chapters will be chiefly concerned with its planting and tending.

SCOTTISH LARCHWOODS. Classic examples of successful High Forest in Britain are the larch plantations of the Atholl estates in Perthshire, which have an interesting history. The second Duke of Atholl introduced the European larch from the Alps to the Scottish Highlands in 1727. His successors, and in particular the fourth Duke, pioneered its planting as a forest tree, establishing ten thousand acres of plantations between 1764 and 1826, involving the planting of 14 *million* trees. This larch has many good points; it is hardy and deciduous, needing neither nursing for protection nor underplanting to preserve the forest soil. Its wood is so durable that thinnings are useful in small sizes for fencing and general estate work; the main timber crop matures in about 70 years and is durable, strong and serviceable (118, 171).

Landowners throughout Scotland followed the lead of the Atholl estates, and it may be said that the modern practice of forestry in Scotland is based upon the cultivation of this foreign tree. In more recent times larch planting has fallen in favour owing to the Larch Canker and the use of seed from unsuitable sources in the high Alps, but this European larch is still largely grown, often in mixture with the native Scots pine. In the meanwhile, two other larches have come into use—the Japanese and the Hybrid, the latter of which originated, appropriately enough, on the Atholl property at Dunkeld. Larch provides an interesting example of successful afforestation with introduced conifers. During the nineteenth century plantations of other foreign species, such as Norway spruce and Douglas fir, were formed on an increasing scale.

ENGLISH OAKWOODS. Whilst interest in Scottish planting centred on conifers, English landlords were striving to raise High Forest woods of oak, a much more difficult proposition. Oak benefits from shelter in youth and underplanting in middle age. It demands good soil, and grows slowly, requiring one hundred and twenty years to attain maturity. Its early thinnings are of low value. But the mature timber commands a high price, especially when it attains large dimensions. On the whole, sentiment rather than economic considerations appears to have caused the overwhelming preference of the English nineteenth-century foresters for this species; for only an exceptionally skilled forester, working under the best of conditions, can grow oak profitably (3).

During the eighteenth century the young oaks were often nursed up by hardwoods of lesser value, such as thorns, holly, and birch. Later on conifers were introduced and used for this purpose. The method was fully described by a Scottish forester, Thomas Cruikshank of Careston, who wrote in 1830 a textbook entitled "The Practical Planter, With a New Method of Rearing the Oak," in which he advocated the planting of Scots pine and European larch nurses from four to seven years in advance of the oak crop. Conifers were also commonly used as shelter belts to protect hardwood crops, and in these ways there arose the mixed coniferous-and-hardwood plantations so typical of English estate woodlands. In such woods, the conifers, even if not removed in the early stages, mature some years before the hardwoods, so that a pure hardwood crop usually remains after their removal.

AFFORESTATION IN IRELAND. The disadvantages of timber shortage in Ireland were realised at an early stage in the history of modern forestry in Britain. Possibly the paucity of the remaining native woodlands was more evident there than elsewhere. By a complicated enactment of William III, 10 Cap. XII of 1698, tree planting was made compulsory on all sizeable estates throughout that country. But in practice little was done, since trees planted by tenants reverted on the expiration of leases to the superior ground landlords, only nominal compensation being payable. Tenants naturally evaded the provisions of this act and others which followed it, until in 1784 an act of George III, 23-24, Cap. XXXIX, granted them property in the trees which they had planted. Thereafter plantations were frequently formed.

In more recent times forestry in Eire has been administered by the Department of Lands. In Northern Ireland it is controlled by the Department of Agriculture.

ESTATE AND CROWN WOODLANDS

The greater part of the woodlands established by the methods detailed above has always been under the private ownership of landowners. On large country estates, the woods are nearly always kept in direct ownership, though the farms around them are usually leased. This policy is influenced by the long-term value of timber crops, and their importance to sporting values. In consequence, the woods are generally managed either by the owners themselves or by their agents. Foresters are frequently employed when the size and importance of the woods makes the technical skill and attention of a full time expert desirable. In 1913 the proportion of woodland in private ownership was estimated at 97 per cent. of the whole (171).

The balance of 3 per cent. then remained in the direct occupation of the Crown, acting through the Office of Woods. The earliest cultivation of the remnants of the ancient Royal Forests appears to have taken the form of coppices. But moved perhaps by the shortage of shipbuilding timber due to the Dutch and Spanish wars of 1652 to 1658, and influenced no doubt by his minister John Evelyn, Charles II enacted the enclosure of three hundred acres of the New Forest, in 1669, for the "propagation of young oaks." William III, by an act dated 1693, increased the area to six thousand acres, but not all of this was systematically planted until the Napoleonic Wars from 1793 to 1815, and the battle of Trafalgar in 1805, again showed the dependence of the navy on home-grown timber.

Similar measures for the Forest of Dean and other former royal forests led to the building up of a national reserve of naval timber (119). Unfortunately, as these plantations reached their prime, the invention of ironclads and steel "Dreadnoughts" ended forever the importance of oak in naval architecture. The younger woods proved adaptable to modern requirements, but the older ones, grown on a system which developed their timber admirably to the use of the old-time shipwright, fell in value when that demand ceased. For they were grown with trees at a wide spacing, to give widespreading crowns with a maximum quantity of bent and forked timber, which formed the "crooks" and "knees" of the wooden hulls. These vital members were selected according to their natural shape, and hewn with the adze to fit their places in the ship's skeleton. The modern circular saw cannot utilize them to advantage.

This predominant concern with naval timber handicapped the administration of the Crown woods until the opening of the present century, when a start was made with more modern methods of afforestation and replanting. This involved the acquisition of new land, as the area of the old royal forests which might be enclosed for tree planting was strictly limited by common rights. The properties of the Office of Woods were transferred to the Forestry Commission in 1923; at that date they included 60,000 acres of actual woodlands.

SELECTION WOODS

In the Chiltern Hills near High Wycombe, and also on certain wooded areas of the South Downs, local foresters have developed another form of High forest very different to the even-aged and artificially grown plantations of larch, pine, and oak, which were established elsewhere. This is the Selection Woodland, which closely follows the conditions of the wildwood. The trees are not planted, but spring naturally from seed, the process being termed *natural regeneration*. They are of varied ages and sizes, and when fellings are made, a due proportion of each age and size is removed, so that natural conditions of competitive growth continue. The principal species is beech, with an admixture of sycamore, whitebeam, and hornbeam. The thinnings provide material for the local turnery and furniture making industries.

NATURAL REGENERATION IN EVEN-AGED HIGH FOREST

As a rule, the felling of a crop of even-aged High Forest trees is followed by its replanting whenever another tree crop is desired. But the same process of natural regeneration that maintains the wildwood and the selection woods, can be employed to replace High Forest Crops. Sometimes, indeed, this occurs without the help of man; pinewoods which have been cut over may grow again from the seeds scattered by a few surviving trees. In the skilled hands of the forester, natural regeneration may become a cheap and effective way of renewing timber crops, and many methods have been elaborated abroad, particularly in France and Germany.

In Britain the best conditions for its employment seldom occur, but what is known as the Shelterwood System has been practised successfully in the former Crown woods of New Forest and the Forest of Dean. "Mother trees" of the mature crop are left at intervals when the felling is made. These scatter seed from which seedlings arise, and shelter the new crop in its early stages. As the daughter seedlings become established, the "mother trees" are gradually removed. Both oak and pine can be regenerated in this way, but success depends largely on seed being plentiful, and seed crops vary from year to year (124, 125).

HOME TIMBER PRODUCTION

Every phase of modern British forestry has been developed to meet a definite demand for timber. The need for this arose first in the smallest material,—hence the early coppices. Later the Standard trees, and the High Forest plantations of oak and conifers, were grown to meet the shortage of larger timber, whilst the Crown woods were managed to meet the needs of the Navy. But during the nineteenth century the demand far outstripped the available supply. The use of coal had ended the former large demand for wood as a household and industrial fuel, and our woodlands were still well stocked with oak and other hardwoods. But industry now demanded softwoods. It called for ever-increasing quantities for new purposes which arose and expanded as commercial expansion progressed. Building timbers, boxboards, telegraph poles, matches, paper pulp, plywood—the call was insistent and increasing. It could not be met from the English coppices or oakwoods, and the softwood plantations of Scotland were insufficient to meet the demand. For a few decades the relics of the old Caledonian forest of Scots pine, last of our extensive virgin woodlands, were ruthlessly felled without heed to replenishment. Then Britain relapsed into dependence on imports. By 1930, only 4 per cent. of the timber used in the country was home grown.

So complete did this dependence become, that a generation of woodworking tradesmen and manufacturers arose who believed that good softwood timbers must invariably be imported. Foreign supplies, carefully graded to suit the market's needs, came forward in unlimited quantities from Russia, Scandinavia, the Baltic, and both eastern and western seaboards of North America. Even pitwood for the coal mines, source of Britain's industrial strength, came almost entirely from abroad. A favourable balance of trade permitted the financing of this enormous import trade with centres of activity in all the principal ports.

Other European countries, faced with the same problems, had systematically conserved their timber-producing forests. But in Britain, woods had been increasingly regarded as sporting preserves and ornaments to private estates. The Great War of 1914 to 1918 saw Britain in conflict with the German Empire, which led the world in forestry practice and had ample timber

118 ENGLAND'S OLDEST LARCHES, PLANTED AT LINLEY, SHROPSHIRE, IN 1739

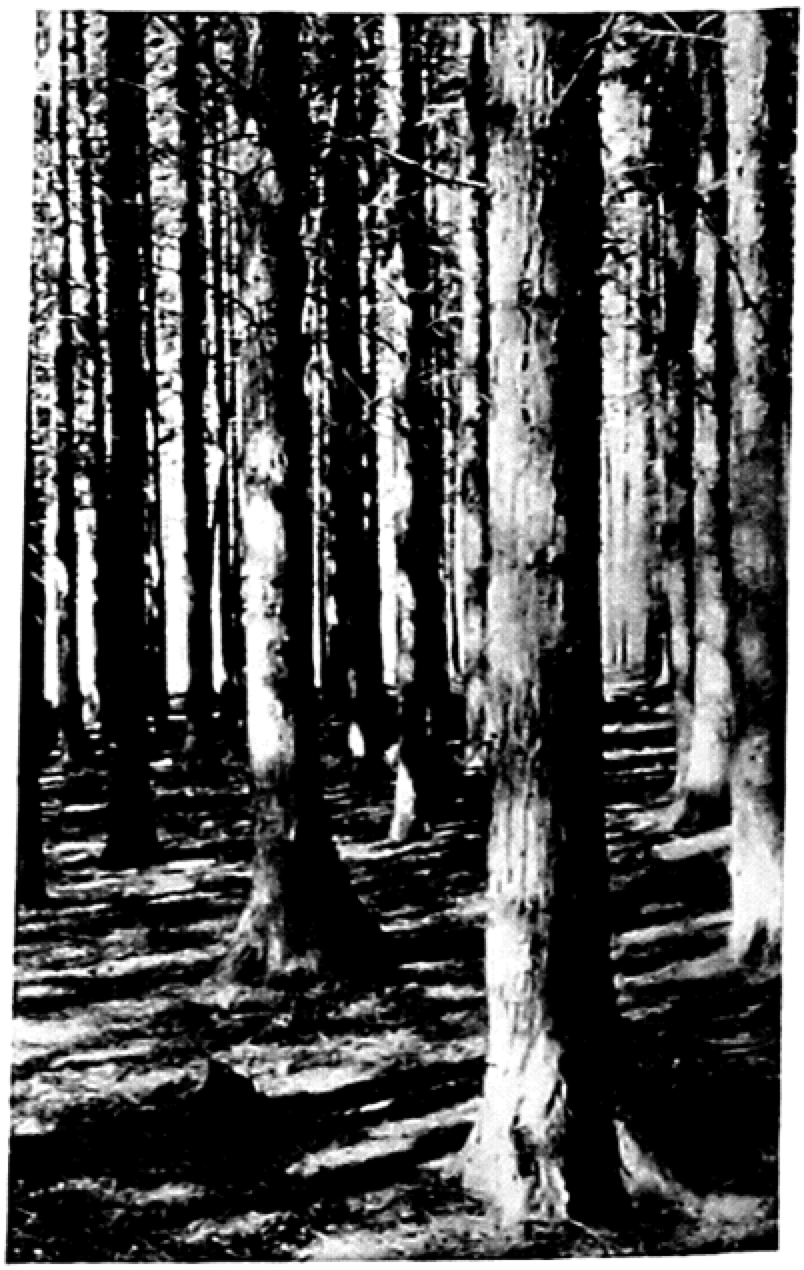
119 OAKS IN THE DEAN NATIONAL FOREST PARK, GLOUCESTERSHIRE. PLANTED FOR SHIP TIMBER AFTER TRAFALGAR, 1805

TREES WITH A HISTORY

120 DEODAR, THIRTY-SEVEN YEARS OLD, BAGLEY WOOD, OXFORD

121 CORSICAN PINE, EIGHTY YEARS OLD, KNIGHTWOOD, NEW FOREST

122 DOUGLAS FIR, FIFTY YEARS OLD, LLANDINAM, MONTGOMERY



123 WESTERN RED CEDAR, THIRTY-EIGHT YEARS OLD, BAGLEY WOOD, OXFORD

OUTSTANDING CONIFER PLANTATIONS

reserves. The remaining British woodlands proved equal to the demands made upon them, but the advent of peace found them seriously depleted. To counter this decline, and to ensure that the country should never again be imperilled through lack of timber, a Forestry Sub-Committee was appointed by the Ministry of Reconstruction. This published its findings in 1918, in what is known as the Acland Report, and recommended the establishment of a state forest authority to carry out a programme of reafforestation.

THE FORESTRY COMMISSION

Established by the Forestry Act of 1919, the Forestry Commission is a government department entrusted with the promotion of forestry throughout Great Britain, and the establishment of state forests for timber production. By 1939, the Commission had acquired 714,000 acres of plantable land, of which 434,000 were under woodlands, mostly planted since 1919. In addition, financial grants had been made to private owners for the afforestation of 126,000 acres. The outbreak of war in 1939 brought renewed demands for home-grown timber. Felling and sawmilling were strictly controlled, and all uses of timber made subject to rationing restrictions.

The urgent need for restoring the nation's timber resources, once again depleted, led the Forestry Commissioners to publish a report on "Post-War Forest Policy," which was issued in 1943. This outlines proposals for creating 5 million acres of effective forest in Britain during the next 50 years. Of these, 3 million acres would be provided by the afforestation of bare land, and 2 million by the regeneration of existing woodlands. This area is estimated to provide, when fully productive, some 35 per cent. of Britain's timber requirements in normal times, and a larger percentage in case of war. It would increase the proportion of land under forests from the present figure of 5½ per cent., the lowest in Europe, to about 10 per cent. Much of this area would be directly controlled by the Forestry Commission, but financial assistance would still be provided for landowners who wished to carry out their own forestry programmes. This policy received Government approval in 1945.

MECHANIZATION

Although the bulk of our woodlands are grown on the same High Forest system that has been practised in Britain for at least three hundred years, the actual handling of the young trees and the resulting timber has been drastically speeded up by the use of modern machinery. The power unit employed is usually either a wheeled or a track-laying tractor, and the adaptations needed for its use in the woods have only been developed in very recent times, mainly since 1930. Nowadays tractors lessen the labour of cultivating forest nurseries, draining and preparing land for planting, and hauling away the timber of the felled trees. Bulldozers have been used for making forest roads and fire barriers, wire ropeways and tramways carry produce down steep hillsides, motor launches tow logs across lakes, and lorries carry poles and firewood from the heart of the woods to the centres of great cities. Some of this equipment has been imported or copied from abroad, but much of it has been devised or modified by our own inventors. New developments are continually being made, always with the aim of cheapening the cost of timber production by lessening the amount of direct human labour required.

RESEARCH AND EDUCATION

Forestry, like other forms of applied science, now bases its advances on a carefully laid foundation of research work. The great length of time that must pass between the planting and the harvesting of a tree crop introduces peculiar problems, but ways and means have been evolved of securing trustworthy results in a comparatively short space of time. Many of the forester's problems can only be solved by the co-operation of other experts,—geologists, botanists, zoologists, entomologists, ecologists, meteorologists, economists, statisticians, engineers, and others. Other questions are peculiarly his own—matters of method or measurement, or the selection and breeding of the most suitable kinds of trees to plant under a given set of conditions. From its inception the Forestry Commission has maintained a Research Branch which has done a great deal of pioneer work in the sylviculture of tree crops throughout Britain, particularly as regards methods of establishing new forests on difficult ground, and the measurement of sample plots of trees of different species and ages (169). At the same time it has furthered research by scientists skilled in other fields, such as entomology and the study of fungi. Other research bodies are the Imperial Forestry Institute at Oxford University, which co-operates with the Imperial Forestry Bureau in spreading the results of world-wide research on forestry problems to all the countries of the British Empire, and the Forest Products Research Laboratory at Princes Risborough, Buckinghamshire, which concentrates on the study of British and Empire timbers (175).

The education of fresh foresters is of course a prerequisite of the continued success and expansion of any programme of forestry, and for many years degree courses have been given to intending forest officers at the universities of Aberdeen, Edinburgh, and Oxford, and at the University College of North Wales, Bangor. The training of foresters and woodmen is arranged by the Forestry Commission at woodland centres in Scotland and England. Interest in the subject is maintained by four forestry societies, the Royal English Forestry Society, the Royal Scottish Forestry Society, the Empire Forestry Association, and the Society of Foresters of Great Britain, each of which publishes an illustrated journal. In these and other ways the work of John Evelyn, the founder of our modern forestry, is carried forward into the future.

The next three chapters outline present-day practice in raising tree crops from the seed to the mature timber tree, and are followed by three more that describe the current methods of felling, transporting, and using timber and other products. These techniques are co-ordinated by the science of Forest Management, which bases its plans on timber measurement and gauges their effectiveness in terms of economic results. The simpler methods of measuring, managing, and financing or valuing forest crops are therefore given in outline to complete this survey of the methods used in modern British forestry.

CHAPTER 14

FOREST NURSERIES

Nearly all the new plantations that are made in Britain are formed by planting out young trees raised in forest nurseries (180). The kind of tree most generally used is called the *transplant*. This means that after growing from the original seed for one or two seasons in its seedbed, it has been *transplanted* to grow on for another year or more in the nursery before being finally lifted for use in the forest. The total age of these transplants varies from two years to four or five, and their height ranges from a few inches to two or three feet. They are therefore both younger and smaller than the trees used for gardens, orchards, or street planting, and as they are planted in large numbers they have to be raised by efficient and economical methods.

Nurseries for raising forest trees either form part of commercial nurseries which also grow trees for ornamental and orchard planting, or else are laid down on woodland estates to provide trees which will mostly be used locally, though some of their produce may also be sold or exchanged. Such nurseries vary in size from a fraction of an acre to a hundred acres or more, and their area naturally varies with the amount of forest land to be planted in the vicinity each season. On an average, each acre of forest land requires 1,750 young trees to plant it up; but wastage and losses occur at every stage of growth from the seed up the thriving tree on its final growing site. Intricate calculations are therefore needed to determine the area of nursery ground required to support a given annual planting programme. But even so, the actual numbers of trees grown to planting size each season are unlikely to coincide with the estimates, and to adjust matters a good deal of exchange or trading is arranged between nurseries to even out supply and demand.

Whatever its size, every forest nursery requires certain essential characteristics. It must be formed on level or only slightly sloping ground, well-drained and free from late spring frosts. The soil must be reasonably fertile, and preferably on the light side, for easier working in wet weather. The area chosen must be soundly fenced against stock and rabbits, and if necessary against hares and deer. An access road is desirable for bringing in materials and taking out the grown trees to the forest. The site must be accessible to labourers and within easy reach of the nurseryman's house, for constant supervision is required.

The three main stages in raising transplants are the collection of the seed, the sowing and tending of the seedlings, and their transplanting and after-care in the transplant stage.

SEED COLLECTION, EXTRACTION, AND STORAGE

The collection of fertile seed for use in raising seedling trees requires a specialised knowledge of the fruiting habit of each kind of tree. Tree seeds vary enormously in size, time of ripening, and average fertility. Plans must be made in advance if a sufficient quantity of each kind required is to be obtained in time for sowing. But forest trees are remarkable for the *periodicity*

N

of their seeding. The causes of this phenomenom are but little understood. One year beech seed, for instance, may be plentiful, but in the next year scarcely a tree will bear fruit, or all the seeds will be but empty and infertile husks. It is the same with oak, though years of scarcity and plenty seldom coincide for the two species; and even smaller seeds such as those of conifers vary greatly in the amount yielded from season to season. With some species, the lean years may be tided over, to a limited degree, by storage.

The principal broadleaved trees ripen their seeds in autumn (21, 23-28). The large seeds of oak, beech, chestnuts, maples, ash, and lime are gathered from the forest floor. Collectors are sometimes engaged and paid so many pence for each pound of seed. The smaller seeds of other broadleaved trees, such as birch, alder, poplar, elm, and willow, ripen rapidly at various times in summer or autumn, and the whole fruit, fruit-mass, or fruiting branch must be gathered from the growing tree at the right stage of development, and the seeds extracted therefrom. A few pounds of these smaller seeds is often ample, for each pound contains many thousands of grains, but their fertility is frequently low.

When dealing with the tiny seeds of conifers, the whole cone must be collected (6, 7, 32-47). This can sometimes be done by means of ladders, or climbing tackle, when seed is required from growing plantations or rare specimen trees. But if a quantity is needed, it is usual to resort to fellings, where the cones can easily be picked up from the fallen branches upon the ground. It is essential to select cones of the right age, for the unripe ones do not yield fertile seed, and the old ones are empty and useless. Many conifers ripen their cones in one season, some in two, whilst a few take three years to ripen. The winter is the usual time for collecting, and useful seed is rarely obtainable from summer fellings.

EXTRACTION. The larger hardwood seeds require but little extraction from their surrounding fruit. Certain of the smaller ones may be extracted by hanging fruiting branches in a fine-meshed bag in a dry place, so that the fruits open and the seeds fall away.

Conifer seed is extracted from the cones of most species by heating them to temperatures of around 100 degrees Fahrenheit, in a dry and airy place for a few hours. Special kilns are usually employed, after which the cones are shaken on wire mesh trays through which the seeds can fall. Larches, and certain pines, require mechanical crushing before the cones will yield their seed. On the other hand, the cones of the Silver firs fall to pieces as soon as they dry after picking, or as soon as they ripen fully on the growing tree. On a small scale, conifer seed may be extracted by the heat of the sun or a kitchen oven, but on a commercial scale, special equipment is required to obtain the highest yield of fertile seed from each batch of cones. It is usual to separate the seed of conifers from their wings by moistening and rubbing by hand, though special machinery has been devised for the purpose.

STORAGE. Some of the smaller seeds of broadleaved trees, such as elm and poplar, do not stand prolonged storage, and must be sown soon after ripening. The larger seeds are usually stored from autumn until the following spring. There are two main methods, dry and moist storage. Dry storage consists simply in keeping the seed in sacks or rat-proof bins in a dry place. Moist storage involves the use of pits or cellars, sunk somewhat into the ground, so that the seed may lie on moist earth or stone, much as it would do on the natural forest floor. It is sometimes mixed with moist sand, and with certain species this method is found to give earlier and more ample germination.

The seeds of certain common trees, including ash, holly, and hawthorn, require storage by special means for a longer period than that of other trees. The process is called *stratification* or *pitting*. After the ripe seed has been gathered in the autumn, it is mixed with moist clean sand and then sunk in a pit, where it remains for eighteen months. Such seeds are called "two-year" seeds, because they cannot, without special treatment, be sown successfully until the second spring after ripening. Other seeds are sometimes pitted for shorter periods.

Conifer seeds are usually stored dry. They retain their germinative power for two or three years, especially if preserved by being kept in sealed jars.

MARKETING, TESTING AND SELECTION. Forest tree seed is a commercial commodity, and a substantial trade is carried on by certain firms of seedsmen in various countries. Prices range from a matter of a few pence per pound for large common seeds such as acorns, to shillings or even pounds for each pound of the rarer, smaller seeds, including many conifers.

Fertility may be gauged by testing samples with incubation methods such as those used for the seeds of farm crops. It is also possible to make a rough-and-ready estimate of general soundness by a "cut test," that is by cutting across a sample of grains to observe their interior condition.

The selection of the best strain of seed is a point of great importance, particularly when it is being imported from a distant country. It is advisable to choose seed from trees growing in a region of similar climate. So far few definite strains of seed are recognized, although research has been started to discover the most desirable varieties. It is therefore all the more important to make sure that the seed used has come from trees of good size and form, and not from stunted or bushy varieties of the trees in question; for the whole future of the next crop depends on the right choice of seed.

Forest tree seed requires sympathetic handling at every stage, for it is a living substance, and its vitality must be carefully preserved.

SEEDBEDS AND SEEDLINGS

The seedlings of forest trees call for great care in their early nursery stages. For in the first year or two of their growth, these tiny plants are subject to attack by insects, animals, and birds, damage by frost, drought, and strong sunlight, and to intense competition by faster-growing weeds. The larger seedlings of broadleaved trees are fairly easy to raise in ordinary garden soil, but specially prepared beds are needed for the smaller seedlings of conifers. Conifer seed only thrives well upon ground which has been inoculated with the fungi that form *mycorrhiza* upon its roots. This inoculation is usually achieved by using the ground for conifer transplants a year or two previously.

The soil for seedbeds must be in good mechanical condition, and this is secured by advance cultivation to give the desired tilth. It should be free from perennial weeds, and, as far as is possible, from weed seeds. Good drainage is essential, but light or heavy soils may be used, provided they are leavened and enriched by adequate supplies of humus. This may be supplied by green-cropping, or the addition of leaf mould or prepared composts. Farmyard manure is useful if well rotted, but is apt to force the growth of seedlings. Chemical manures are of little assistance without added humus. A high humus content produces a soil resembling that of the forest, where the natural seedlings are found to thrive best on soil enriched by the decay of fallen leaves.

The prepared soil is thrown into raised beds, to secure adequate drainage, aeration, and freedom from surface rain-wash. These beds are normally about one yard wide, and stand some three inches above the level of the intervening paths, being as long as may be required. Sometimes they are boxed-in with boards to support the sides. They are usually thrown up with the spade in spring, the usual season for sowing, raked smooth and firmed down with the back of the spade or a roller.

SOWING TREE SEEDS. Two methods of sowing are used, but as there is little difference in the results, custom or convenience decides which to adopt. In *broadcast* sowing, seed is sprinkled evenly over the whole bed. In *drill* sowing, shallow drills or rows are made some six inches apart; drills may be formed with a hoe or a special ribbed roller. Machine drills, which deposit the seed in a drill formed automatically as they are pushed along the bed, are sometimes used when large quantities of seeds have to be sown.

Before sowing, most seeds are soaked in water for 48 hours to assist germination. They are then drained, dusted with red lead to ward off mice, and dried a little. Then they are sprinkled over the bed in broadcast sowing, or along the drills in drill sowing. It is necessary to estimate the area which each pound of seed is to occupy, for large seeds such as acorns require only one square yard of ground to each pound of seed, whilst fine conifer seed needs from fifty to one hundred square yards per pound. A thin layer of fine soil may be used for covering the seed, but small conifer seeds give better germination if covered with coarse clean sand or fine grit.

TENDING SEEDLINGS. Seedbeds require constant weeding to preserve the tiny trees from overbearing weeds. This must be done largely by hand, and is a slow and tedious process. The weeders have to recognize each kind of tree seedling, in order to avoid mistakes. Conifer seedlings are minute, and do not much resemble their parent trees; in their youngest *cotyledon* stage they closely resemble seedling grasses or young spurrey. Weeding is easier if seed is sown in drills covered with white sand, for the rows of tiny trees are then clearly defined against the darker earth.

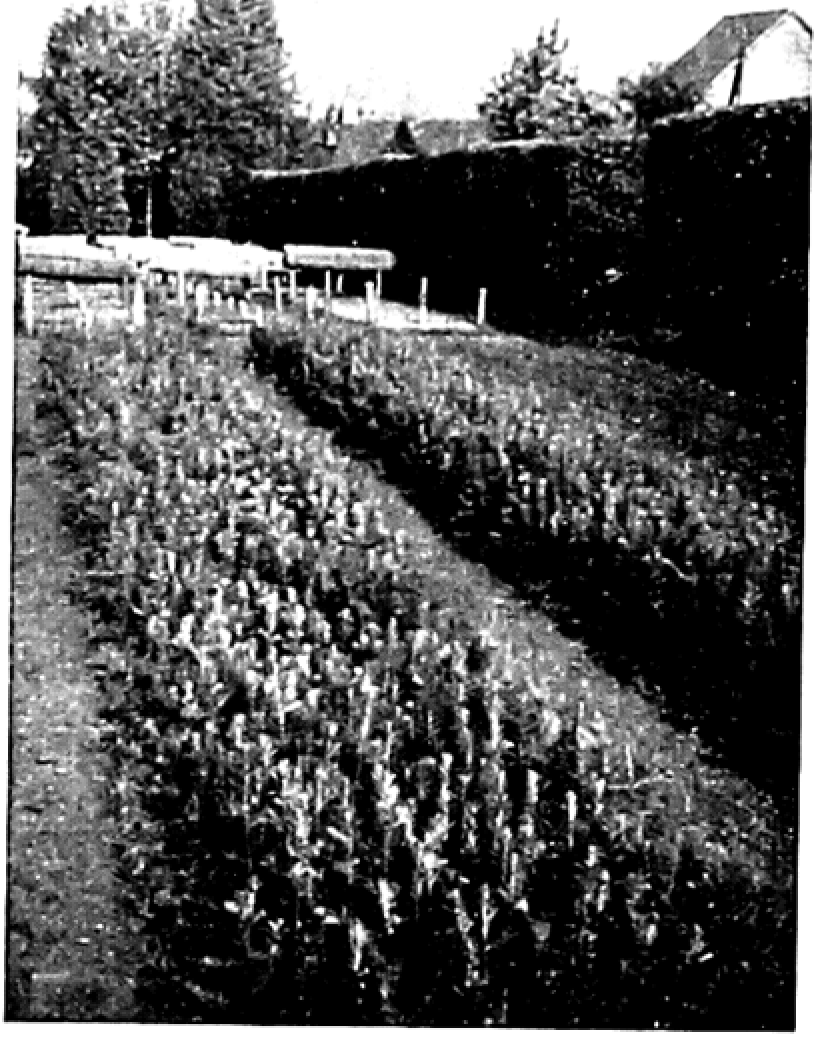
Seedlings must be protected against animal enemies. Red lead keeps away mice, but only trapping will discourage moles from wrecking the seedbeds with their underground runways. Birds attack large seeds, pheasants being very partial to acorns. Sometimes small birds seek out young seedlings in their tender cotyledon stage, when only the first seed-leaves are showing; if the attacks are persistent the beds must be covered with wire netting, or a bird-scarer employed.

Insect pests are local in their attacks, but can be very troublesome. A soil caterpillar called the cutworm, *Agrotis segetum* Sch., may prey intensively on tree seedlings, though herbaceous plants form its more usual diet. It may be caught beneath inverted turves set on or between the beds, for it is nocturnal in habits and must seek shelter throughout the day. The same traps are sometimes effective for the fat white grubs of the cockchafer (*Melolontha* and allied beetles), but this is a most serious pest and seedbeds should never be formed on ground known to be infested with it. Its underground feeding tunnels are shown by trails of dying seedlings, and it may at times be caught

124 PINE OF VARIOUS AGES AT ALICE HOLT FOREST, HAMPSHIRE

125 ASH, TWO YEARS OLD, AT HOLKHAM, NORFOLK

NATURAL REGENERATION OF FOREST TREES



126 LARCH SEEDLINGS, KENNINGTON, OXFORD

127 SPRUCE SEEDLINGS, BENMORE, ARGYLL

128 TWO-YEAR-OLD TRANSPLANTS OF VARIOUS SPECIES, ALL FIT FOR FOREST PLANTING, INCLUDING OAK, THUYA, THREE SPRUCES, DOUGLAS FIR, AND TWO LARCHES

by digging at the head of this trail. In winter it burrows deeper below the soil, but if the ground is ploughed up in summer it may be possible to collect large numbers of the grubs by hand.

Fortunately, the forester has valued allies in the form of insectivorous birds, many of which also do useful work by eating weed seeds. Except on those rare occasions when, for reasons known only to themselves, they elect to attack tender seedlings, every variety of small bird may be encouraged in the forest nursery. Pied Wagtails are especially frequent and useful.

Certain fungi attack trees in the seedling stage, particularly oak, European larch, and thuya. Fortunately, where many small trees are closely concentrated in a small area, the nurseryman can combat mildews and similar fungal affections effectively with chemical sprays.

Finally, the extremes of weather may take heavy toll of tender seedlings, particularly those kinds which benefit in a natural state from the sheltering effects of taller trees nearby. Certain tree species, notably the spruces, require overhead shelter from the sun in hot dry weather. This is provided by means of screens of laths or hessian supported on short posts and wires; such screens must be readily removable to permit of the beds being weeded. On some soils *frost-lift* occurs in winter. The soil freezes, expands, and lifts the seedlings out of the soil. The thaw leaves them stranded, and they seldom recover. Screens also protect them against this peril, and another remedy is to mulch the soil with leaf-mould, which does not move to the same degree when frozen; only small seedlings or recently moved transplants suffer.

LIFTING SEEDLINGS FOR TRANSPLANTING. Tree seedlings are kept in the seedbeds for one or two seasons, being weeded and tended during this time. Many kinds may be lifted after one season only, especially if fertile soil has promoted rapid growth. Oak, Sweet chestnut, and Scots pine are frequently big enough to move the first year. Smaller seedlings, such as the spruces, may need two seasons in the seedbeds (126, 127).

Lifting can only be done in the late autumn, winter, and early spring, when the plants are dormant. They are carefully raised with garden forks, all useless plants or *culls* rejected, and the sound trees tied up in bundles of a hundred, for transport or transplanting in the home nursery. Occasionally seedlings are used for forest planting, but the only species with which this proves generally satisfactory are oak and Sweet chestnut.

Wild seedlings of natural origin, taken from the woods, seldom give good results either in nursery beds or when replanted in the forest. Their root systems are not adapted to transplantation, though they may develop into fine trees if left undisturbed.

Seedlings suitable for transplanting vary in size with age and species, from a few inches up to a foot or more in height. Very small seedlings seldom form successful transplants; but on the other hand those which exceed two years in age or one foot in height do not usually produce a transplant well suited to forest conditions.

Trees are often transferred from one nursery to another in the seedling stage. If carefully packed, protected from frost, and not crowded too closely when in transit, the bundles of seedlings may be sent long distances by steamer, road, or rail. Except when actually travelling, they have to be *heeled-in*, that is set with their roots below ground level in soft earth, to keep them moist and safe from frost.

TRANSPLANTS

The third and final stage in raising young trees for the forest is transplanting. The purpose of this is to develop their root systems so that they will withstand the shock of removal to the less hospitable conditions of their final forest home. Plants equally large might be obtained by allowing seedlings to remain for an extra year's growth, but these would develop a strong tap root, with weak side roots and too long a shoot, and few would survive the change to the rougher soils and surroundings of the forest. Transplanting causes the trees to develop a system of fibrous side roots, for the tap root is broken or checked when the seedling is lifted, and it must develop lesser roots or perish. At the same time, shoot growth is checked also, and the result is a "better-balanced" plant, having a small shoot in proportion to its root development.

LINING-OUT. Transplanting in the forest nursery is generally referred to as "lining-out," as the young trees are set for convenience of working in a series of straight lines. Ground that is well-drained, free from weeds, and in good heart, is chosen for the purpose, and is ploughed or dug by hand before the work begins. Lining-out may be done in open weather between October and April, but hard frost stops it completely. The *lines* or rows of plants are usually from six inches to one foot apart, and the distance left between each plant in the rows varies from one to three inches. This spacing naturally affects the numbers of trees which can be lined out on a given area of ground. At two inches apart, in lines one foot apart, each little tree needs 24 square inches of growing space. This gives in round figures, 50 plants to each square yard of ground, or 1,000 trees on every 20 square yards, and about 200 *thousand* trees on each acre.

Two methods of lining-out are used, but in both a trench one spit deep is cut with a garden spade along a straight line marked out by using a pegged string. In the simplest method, the workers place the seedling trees against the side of the trench at the correct planting depth by hand, judging the spacing between them by eye. Then they press a handful of soft earth against the roots, which holds the young trees upright and in place until the whole trench is filled in again with the spade, and the young trees firmed-up by foot pressure.

Lining-out with *boards* is a somewhat more complex process, as it is usually arranged to give some division of labour between the members of the transplanting gang. The *lining-out boards* are made of wood with metal fittings, and their purpose is to hold a large number of seedlings, at the correct planting depth and distance, along the edge of the trench whilst the soil is thrown back against the tree roots and made firm. Once this is accomplished, the boards are removed and refilled with a fresh supply of seedlings. Each board consists of three main members; a fixed frame board, some ten feet long, four inches wide, and three-quarters of an inch thick; a hinged closing board, somewhat narrower and thinner; and a small spacing bar, which regulates the distance apart at which the trees are planted.

The board-fillers, who are usually the weaker members of the gang, such as women or boys, set up the boards on a trestle, set at a convenient height in the lee of a light screen or windbreak, which serves to shelter the delicate tree roots from drying winds. There they deftly set the little seedlings in position on the main frame of the board, one to each gap in the spacing bar, and each with its roots at the correct position for depth of planting. When the whole board is full, they secure the seedlings in place by turning over the closing board, and fixing it with a clip. Then they carry the whole contrivance, with its load of little trees, to the open trench, and put it down so that all the tree roots lie within the opening in the ground, pegging it so that it remains upright whilst the trench is filled in (129–131).

The stronger members of the gang, such as the men workers, now come along to fill in the trench with their spades, throwing earth against the tree roots and firming it with their feet. As they pass along the line, the board-fillers return, unpeg and unclip the boards, and lift them free of the trees, which are revealed as a neat transplanted row. Meanwhile the spade-workers, having filled in one trench, proceed to open the next, and so the work goes on. All this is done speedily with rhythm and co-ordination by a well-trained transplanting gang, and the onlooker sees the lines of transplants being formed continuously before his eyes. The average number of trees lined-out in a working day may reach two thousand or more for every worker, which means four trees per head per minute! Even this figure has been exceeded with new machinery devised to do the spade work.

TENDING TRANSPLANTS. Transplants growing in lines are hardier than seedlings, and require little attention apart from regular weeding. No matter how carefully the lining-out is done, some losses, perhaps 10 to 20 per cent. of the original number, usually occur during the first year. The transplants may be lifted after one season's growth, or, if not required then, be left to stand and grow on for a second or even a third year. If they still cannot be used in the forest, they may be kept in a usable condition by a second transplanting, to check shoot growth and encourage root formation still further. Such plants are known as *twice-transplanted.* They are naturally older, larger, and more expensive than the general run of simple transplants, but thrive better under forest conditions which call for a sturdy well-rooted plant.

LIFTING AND DESPATCHING TRANSPLANTS. Transplants are lifted from the nursery lines as required during the forest planting season, which lasts from October to the end of April. They are raised with spades or forks, care being taken to leave their roots intact and unbroken. Any misshapen or undersized trees are culled out. The remainder are tied up in bundles of fifty or so, for despatch by road or rail to the forest. Straw or bracken packing is used to protect them from frost, and to keep their roots moist during the journey. Whilst awaiting transport or planting, the transplants are " heeled-in " in moist earth in some sheltered spot, their roots being laid in a shallow trench and covered with soil. In their dormant state they may be sent over long distances without ill effects, provided they are not crowded too closely in lorries or railway vans, but are left some breathing space. If packed too tightly, or with their foliage wet, they are liable to heat up, and many may die.

Transplants vary widely in size according to age and species. A usual height for Scots pine raised from a one-year-old seedling in one year's growth as a transplant (a " one-year-one " or " one-plus-one " transplant, two years old in all) is 6 inches. The same kind of tree if grown for two years in the seedbed and two years in the transplant lines (a " two-year-two " or " two-plus-two " transplant, four years old in all) might average 2 feet tall. These are useful practical limits for most forest trees. Anything smaller than six inches is unlikely to thrive, whilst trees over two feet tall often fail to take root satisfactorily when transferred to the forest (128).

CUTTINGS. Certain forest trees, in particular the poplars and willows, are rarely raised from seed. Cuttings are taken from selected trees, and set in lines in nursery soil. They usually take root very readily, and after growing for a season or two are fit for planting in the forest. Young branchwood is usually chosen, and cut into lengths about nine inches long; the work is done in winter, when the boughs are leafless.

SUCKER SHOOTS. A few trees, notably Field elm and aspen, are most readily propagated by using the sucker shoots which arise from the roots of old trees (117). These are lifted and usually grown for a year in the nursery before being replanted in the woods.

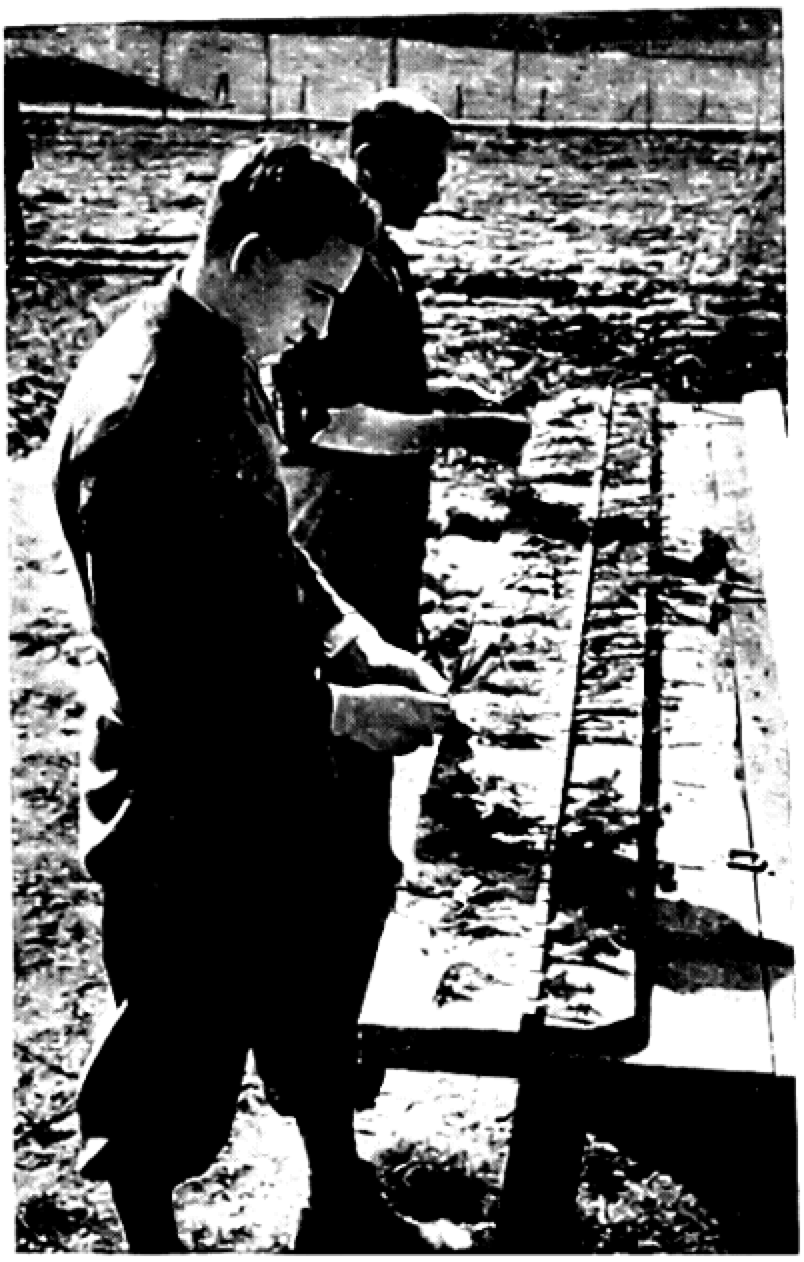
GRAFTING. Selected strains of most forest trees, even including the conifers, may be increased by grafting upon coarser or commoner stocks. Owing to the cost and trouble involved, grafting is seldom resorted to for trees grown commercially as timber. It is commonly used for some ornamental trees, such as *weeping* varieties, and has been employed successfully abroad to speed-up the slow process of artificial tree breeding.

NURSERY MANAGEMENT

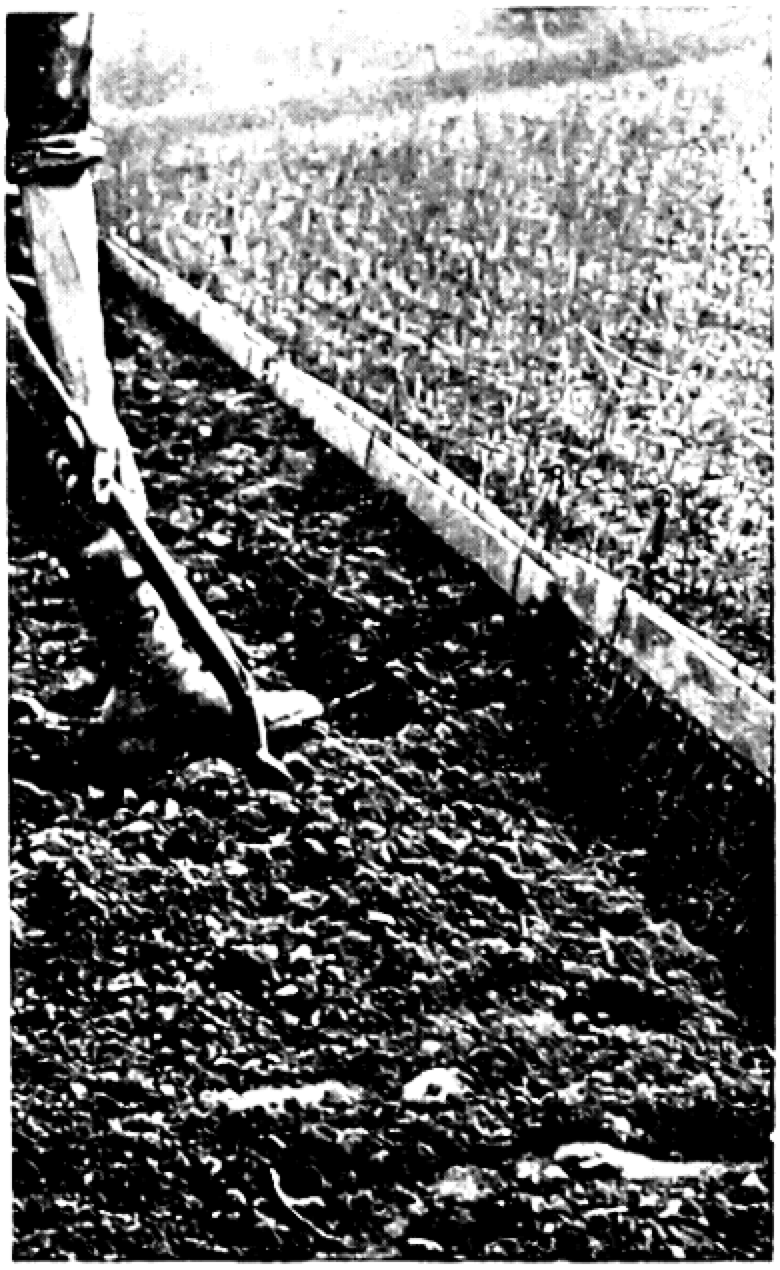
The work of seed sowing, transplanting, and lifting young trees for the forest has all to be concentrated into the dormant season of plant life, from October until April. But for the rest of the year the nurseryman and his staff are far from idle. Throughout the heat of the summer they have to weed the seed-beds and lines constantly to prevent the tiny trees from being overwhelmed. In the autumn there may be seed collections to carry out.

In most forest nurseries an area of ground is kept in reserve, for in order to maintain fertility a portion of the ground should be rested each year. This may either be left fallow or used to grow a green crop for ploughing-in. The growth of such a green-manuring crop is often aided by a dressing of farmyard manure, or chemical fertilisers.

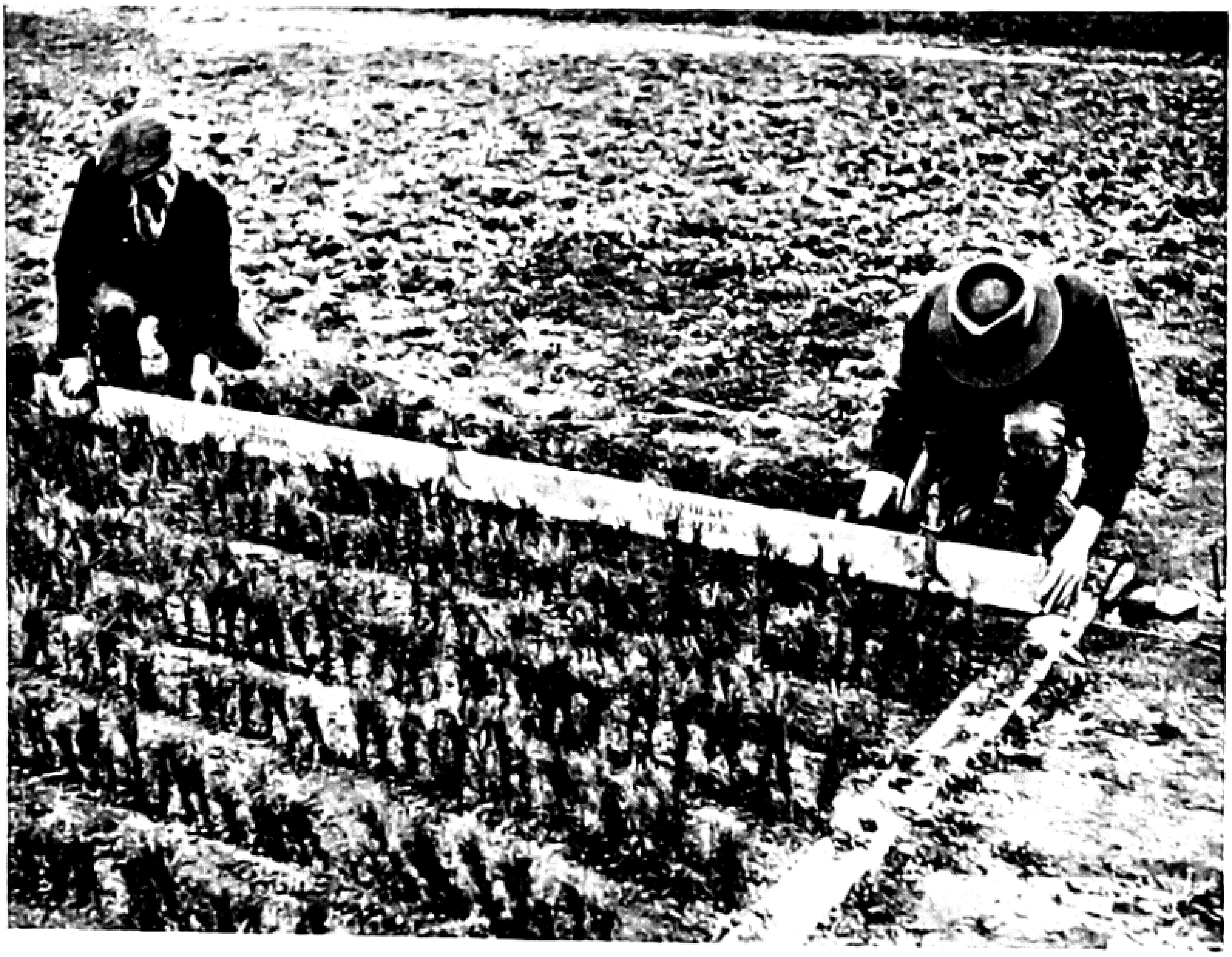
Each year the man in charge of the nursery has to make a careful stock-taking of his growing stock of young trees. This is usually done in late summer, so that the success of the spring sowings and transplantings can be assessed, and plans made in advance for using the stocks that will be fit for lifting in the autumn. Each season brings a steady turnover of thousands or even millions of little trees, growing rapidly through their various nursery stages. Raising the timber trees of the future is a fascinating task which is worth doing well, for the nursery forms the foundation of the forest's growing stock.



129 FILLING THE LINING-OUT BOARD (SPRUCE)

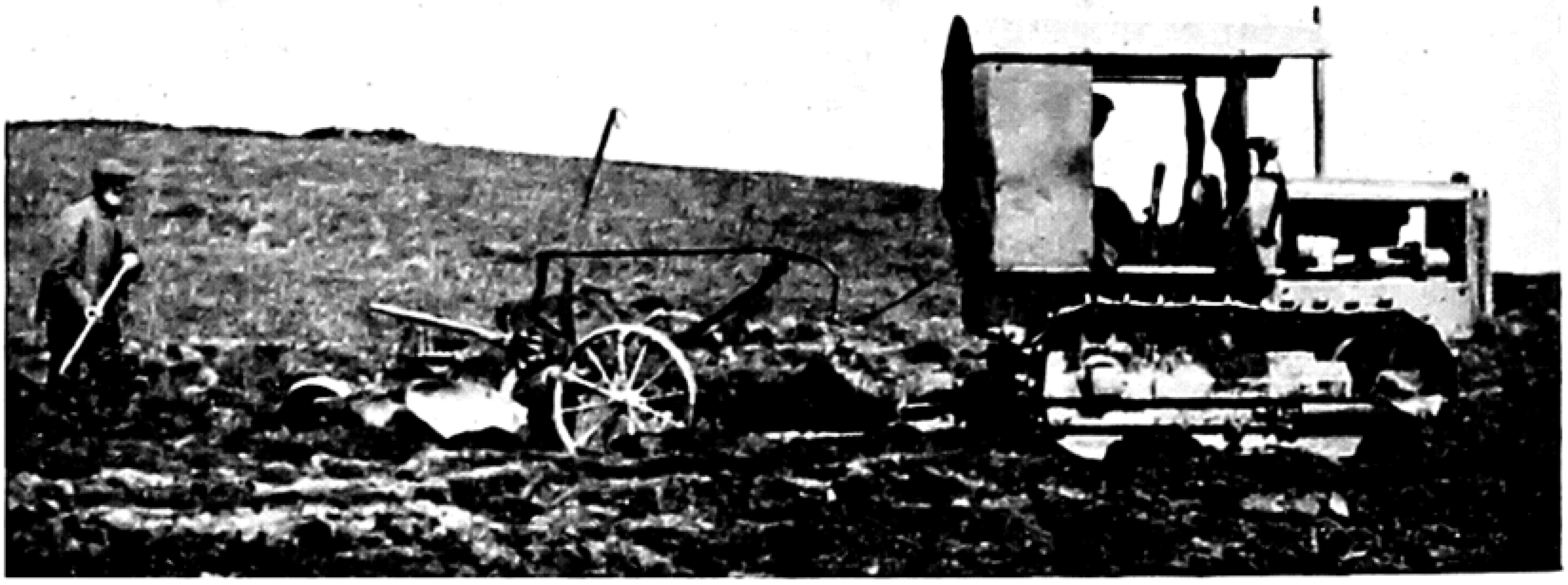


130 EARTHING UP THE ROOTS (BEECH)



131 REMOVING THE BOARD AFTER LINING-OUT (SCOTS PINE)

STAGES IN TRANSPLANTING SEEDLINGS



132 PLOUGHING THE MOORLAND AT CLOCAENOG FOREST, DENBIGHSHIRE

133 NOTCH-PLANTING SCOTS PINE

CHAPTER 15

AFFORESTATION

The creation of new areas of woodland is called "afforestation" whilst the replanting of woods that have been cleared of their timber is termed "re-afforestation." Either operation requires a long term investment of capital in the tree crop, and the setting aside of an area of land for the fixed purpose of tree growing for a long term of years. Although pit props may be harvested only 20 years after planting, from 60 to 100 years or more are needed for the growing of *timber* crops in Britain. Consequently, afforestation is undertaken mainly by those individuals or groups who have a long term interest in the countryside and its resources. These include landowners and rural estate companies, continuing corporate bodies such as colleges, water supply undertakings, local government bodies, and, in its own particular sphere, the state forest authority (158, 170).

The individual or authority undertaking afforestation must be reasonably sure of funds being available for several years ahead. Until the new forests yield monetary returns, they will demand a continuing outlay for maintenance and overhead expenses. Where mature woodlands already exist upon the estate, the income derived from felling a portion of them may finance the development of new woods. Otherwise, the costs of the first years must be met from outside sources, as is the case with many other forms of capital investment. To lighten the heavy initial charges, financial grants are made by the government through the Forestry Commission, whilst the Inland Revenue authorities make special concessions to woodland estates, particularly in the matter of death duties.

The provision of land and capital are essential considerations for the owners and managers of a forest property, who also decide the policy and purpose for which new woodlands are required. Timber production, at a profit, is normally the first consideration, but other reasons for the creation of woodland are the need for cover for game, shelter for farmlands, improvement of water catchment areas, improvement of scenery and general estate amenities, and the provision of reserves for the study of natural history and the scientific aspects of forestry.

On a large estate, the total area of land to be afforested is usually divided into blocks, to be dealt with in turn year by year. The work can then proceed steadily under the constant supervision of a trained forester or other estate employee who is skilled in forestry. This chapter is concerned, in the main, with current practice in establishing new plantations.

REAFFORESTATION

The replanting of land which formerly carried woodlands is in some respects an easier operation than the initial planting of trees on waste lands. A forest soil already exists, and frequently there is a system of roads or rides dividing the area up into convenient blocks. Often, too, the prospects of the new crop may be judged by the success or failure of the previous one, and this may influence the choice of the kind of tree to be planted.

On the other hand, the ground has to be thoroughly cleared of the remains of the former crop. These takes the form of branchwood or "brash," the smaller twigs and branches of the felled trees, which are usually piled together and burned; and "cordwood," consisting of the larger branches, which are stacked into regular heaps called "cords," normally 8 feet long, 4 feet high, and 4 feet through, for sale as firewood. Often the timber merchant who fells the area does this work under the terms of his contract, the operation being termed "clearance of lop and top."

In most hardwood areas that are reafforested, coppice or stool shoots arise for some years from the old stumps; these shoots have to be cut back at some cost. This trouble is usually most intense on former Coppice or Coppice-with-Standards woodlands, during their conversion to modern High Forest plantations.

Another reafforestation problem arises in former pinewoods, where the Pine weevil (*Hylobius*) frequently occurs in great abundance for a few seasons after felling, and attacks the young conifers planted as a replacement. The remedies adopted are the postponement of replanting for a few seasons, and the trapping of the weevils. In any event, it is advisable to delay the replanting of land that has carried a heavy crop of conifers for a year or two after the felling, to allow the soil covering of raw humus to decay. Undecomposed needles are an unfavourable medium for the growth of either seedlings or transplanted trees.

On the whole, reafforestation is a surer method of obtaining good plantations than is new planting. Besides the great advantage of a ready-made forest soil, shelter can frequently be obtained by leaving trees of the old crop standing as belts or wind-breaks. Large, sturdy plants may be used under such conditions, and these soon outgrow the competing weeds to form well-established plantations whose early growth is usually rapid.

NEW AFFORESTATION

The planting of woodlands on new ground is normally limited, in Britain, to the poorest of soils. Agricultural land is too valuable, and the area available too limited, for it to be used to any great extent. Consequently the forester has to plant up the sandy heaths, the shallow-soiled chalk downs, the peaty moorlands, and the steep rocky hills from which the farmer cannot wrest a living. Under such conditions of soil and exposure the growth of the first tree crop is inevitably slow at the start, and often compares unfavourably with the growth of replanted woodlands.

The variety of trees which can be grown as a first crop on new land is generally limited by these adverse conditions. Most of the land available for afforestation may be described as marginal, at the outset, for tree growth of any kind, although the forests may be expected to enhance its suitability for further tree crops after the first one has gained a foothold. The selection of the tree species is a matter for careful consideration or expert advice. Broadleaved trees seldom succeed as the first crop, unless nursed up by a conifer.

Many of the poor tracts of land available for afforestation can be much improved by ploughing. This is a modern advance in forestry technique made possible by the use of tractors and the development of heavy duty ploughs. Ploughing cannot be done in old woodland, because of the stumps, nor on rocky ground. Elsewhere, ploughing in some form or other is generally beneficial. Not only does it enhance the fertility of the soil, but it checks weed growth, reduces fire risks, and does away with the need for marking out lines for planting the rows of young trees. Its cost is saved, wholly or partially, by reduced planting and weeding costs (132).

The best method and depth of ploughing varies with soil and site. On damp hill sides, especially in high rainfall areas, " partial " ploughing is resorted to. A furrow's width is left unploughed between each ploughed furrow. This leaves open furrows which serve as drains, as they are usually cut to run downhill. Where " pan " is present, as often occurs on moorland soils, heavy ploughs of great structural strength are used to delve a foot or more deep in order to break it up. On drier sites, where open drains are less necessary, the full ploughing of the ground in the usual agricultural fashion is sometimes preferred.

Whether the land is ploughed or not, rides and access roads have to be planned systematically to give ways of approach and to check the spread of possible forest fires. Often the rides are ploughed up and then harrowed to form a smooth surface, passable by vehicles in dry weather, which forms a barrier to spreading fires; a width of at least ten yards is required.

FENCING

Whether new planting or reafforestation is projected, fencing is nearly always required to safeguard the crop in its early stages. The type of fencing used varies in different localities. As a rule, wire netting must be employed to check the ubiquitous rabbit. A height of three feet of netting is needed, with an additional six inches buried below ground to stop burrowing, and the mesh must be small, no larger than one-and-a-quarter inches. This netting is usually topped by a strand of plain or barbed wire, and the whole is supported on stakes or stobs. Where a long fence has to be erected, straining posts are added, and the main wires are made taut by the use of wire strainers. Such a fence is costly, but economies are possible by enclosing large areas at a time, and by buying the wire netting at a wholesale rate. Within the fenced area, all rabbits must be exterminated before planting begins.

In some districts a six-foot fence is needed to keep out deer. The upper three feet may be of wires or broad mesh netting, but the lower three feet has usually to be rabbit proof. Where rabbits and deer are rare, stock-proof or sheep-proof netting may suffice.

DRAINING

Marshy areas require draining before afforestation can proceed. Open ditches are the rule, for tree roots would soon clog tile, pipe, or mole drains. Drainage is often assisted by carefully planned partial ploughing, for the open furrows serve as subsidiary drains which can be linked up with the main drainage system, By this means, large areas of land formerly looked upon as useless have been successfully afforested. But the plough cannot be used in old woodland, where the drains must be cut or cleared by hand.

CHOICE OF SPECIES

The selection of the best kind of tree to plant on any area that is to be afforested or replanted is a matter best decided by an expert forester who knows the actual ground. Choice is influenced by such considerations as the nature of the land, its soil, climate, and surface vegetation, the purposes for which the forest is required, and the probable markets for timber. As an instance of the importance of vegetation, heather suggests the pines and usually rules out the spruces and certain other conifers. A strong growth of Blue Moor grass (*Molinia*), on the other hand, indicates land suitable for spruce. Bracken and gorse grow on more fertile soils adapted to a wider range of conifers and some of the less exacting broadleaved trees. There is no one ideal tree suited to all the varied soils, climates, and local conditions of the British Isles. Our forests are always likely to be as varied as the other aspects of our countryside.

Comparatively few of the very many different kinds of trees grown in our parks and gardens are used for forming plantations. Those which are commonly planted at the present time are described below. The conditions under which they thrive call for expert study, but some idea can be given of their relative importance in current forestry practice.

THE PINES. Scots pine is one of the most widely planted and adaptable of trees. It is often used as a nurse for less hardy species on exposed afforestation areas, and it is one of the few trees that really thrive on heather-clad land. It is at its best on light soils in low rainfall districts. Corsican pine is often preferred in the south and east of Britain, as it yields timber at a quicker rate than the Scots pine, and is less subject to attack by the Pine Shoot Moth (*Evetria*) (121, 134, 135).

LARCHES. Although widely planted in the past, European larch is now generally restricted to specially favoured situations, as it suffers from cankers and other troubles. Japanese larch has proved a healthier, more adaptable, and quicker-growing tree, and is particularly successful in certain high rainfall areas of the western mountains.

DOUGLAS FIR. This conifer requires fertile soil but gives a rapid yield of timber, and is favoured for sheltered situations, especially in the west (122).

SPRUCES. The spruces are valued for the high volume and rapidity of their timber yield, even on high-lying land of low fertility. They dislike heather land, and benefit by nursing with Scots pine on exposed sites in their early stages. They grow best when planted on turves or through the slices from plough furrows. Sitka spruce tends to yield timber more rapidly than the Norway variety (169), but the latter resists frost better.

OTHER CONIFERS. Lawson cypress, thuya, hemlock, the Silver firs and various other species are all used to form plantations on a lesser scale, usually on better ground than that allocated to the commoner species (120, 123).

BROADLEAVED TREES are most frequently used for the reafforestation of former woodland, for land of sufficient fertility for their needs is seldom available for new afforestation. Beech is an exception to this rule, for it thrives better than the conifers on chalk downs, though coniferous nurses are often employed to bring it through the early stages.

Oak, ash, Sweet chestnut, and sycamore require fertile soil and shelter in their early stages, whilst the planting of poplars is usually confined to selected streamside areas. Birch, alder, and aspen are rarely planted, though they occasionally arise naturally and are retained as a crop. Few other hardwoods are grown in plantations, except on a small scale or for ornamental purposes.

The emphasis on conifers is the result of two factors, the low fertility of the available land, and the overwhelming demand for softwood timber. 94 per cent. of the country's timber requirement is for softwoods.

PURE AND MIXED PLANTING. It is frequently advantageous to plant trees of different species in mixture. Complex mixtures are difficult to control as they grow, but simple " line-and-line " mixtures of two species are more easy to manage and may give a better or an earlier yield than pure plantings of the same two species.

One of the two trees chosen is normally hardier than the other, and is regarded as a nurse to help the more delicate partner to grow through the difficult early stages. In youth, many broadleaved trees thrive best in mixture with a conifer, which can be cut out when the " pole " stage is reached, leaving a pure hardwood crop to grow on as timber. Typical mixtures are beech with Scots pine on chalk, and oak with larch on richer, loamier soils. Some conifers benefit by nursing, and the frost-tender spruces start best in company with hardier pines or even with birch.

THE TECHNIQUE OF FOREST PLANTING

So far we have considered only the preliminaries of forest planting—the allocation of land and capital, preparation of the ground by clearing or ploughing, draining and fencing, and the all-important factor of choice of species. All this is work which can be planned well in advance before the actual planting commences. Another essential factor which requires prior consideration is plant supply. Whether the plants used are raised on the estate or bought from an outside nursery, the numbers required, by age, size, and species, must be calculated well in advance, and it is the usual practice to obtain samples which show their size and quality.

The planting season commences in October, and continues, unless interrupted by deep snow or frosty weather, until April. It is therefore longer in Britain than in most parts of continental Europe or North America, where the severer winters restrict planting to a few favoured months. Here the work may continue from autumn to spring, though on the whole the earlier planting gives the best and surest results.

LINING AND SPACING TREES. The first task in the actual tree planting is the marking out of the lines along which the trees are to stand. On ploughed land, the furrows serve as lines. Elsewhere it is necessary to set up "sighting rods " to obtain a straight alignment; this is usually done as planting proceeds. The usual practice is to espace the trees on a square pattern; rectangular or equidistant triangular spacings may also be used, but have few advantages in practice. A very common planting distance is 5 feet apart each way, requiring 1,750 trees per acre. Both wider and closer spacings have their advantages; wide spacing is cheaper at the outset, but the trees fail to clean their side branches so well as those planted closer together, and the failure of any tree leaves a wide gap in the crop. The spacings favoured therefore range as a rule between 4 and 6 feet; poplar and willow are exceptions, being spaced from 20 to 40 feet apart.

PLANTING TOOLS AND METHODS. Four types of planting tools are commonly used in Britain, each with its own method for preparing the planting position and inserting the young tree. The best one to use varies with local soil conditions and the size of the trees.

Ordinary garden spades, which have a bent shank, are used in *pit-planting*. A definite pit is excavated, and the tree is inserted in the loosened earth to the correct depth, the soil restored to its original level, and the whole firmed up with the planter's boot. This is the best method, especially for the larger trees, but unfortunately it is slower and more costly than the others.

Notching spades, distinguished by their *straight* shanks, are very widely used for the simpler and cheaper method of *notch-planting*. In this the spade is driven down vertically to form a straight notch, and then inserted again at right angles to make either an L- or a T-shaped incision in the ground. After the second stroke, the blade is levered up to open a gap at the angle of the strokes of the L or T. The young tree is then inserted in this gap, drawn to the correct depth, and then the notches are allowed to close and are firmed up to hold it (133).

The various patterns of notching spades include the "Mansfield," which has tapering sides to the blade, and the "Schlich," with the sides of its blade convex and meeting in a point; in still other forms, the blade is slightly hollowed so as to give a certain amount of leverage when notching.

A very different type of tool, used for notching-in small plants, is the mattock. This is a hand tool similar to a pickaxe, but with a broad blade; specialised types are known as "cross-axes" and "two-bills." On certain types of rocky, stony, or ploughed ground, the mattock proves a cheap and effective tool to work with.

The semi-circular spade is used for a modified form of pit-planting in suitable soils. It has a scoop-shaped blade on a long straight shank, at the top of which is a long handle. This is turned with both hands after the fashion of an auger, and the feet are not used. It cuts out a small pit neatly and quickly, but is unsuited to work in stony soils.

TURF AND MOUND PLANTING. On marshy ground the best results are often obtained by planting the trees on the tops of small mounds, or in or through grassy turves; these methods are specially suitable for the spruces, which have a shallow root system and are checked if planted too deeply. Turves can often be conveniently cut from the drains which are necessary in such areas. Where large areas have to be dealt with, suitable turves are provided quickly and cheaply by using a suitable type of plough to prepare the ground. At the same time the plough opens up an extensive series of shallow drains in the form of plough furrows, providing a rapid method of preparing large areas of ground for afforestation, The development of this technique has enabled the Forestry Commission to plant up large stretches of moorland which were formerly regarded as useless for any purpose.

PLANTING PROGRESS. Those who are only familiar with the planting of trees in gardens or orchards may be surprised by the speed at which experienced forest workers plant small trees on a forest scale. A tree is planted every minute on easy ground. Quick work is essential not only on the grounds of economy, but also because of the large numbers of trees to be dealt with and the wide areas involved. Given good plants of suitable size and species, and reasonable weather conditions, a surprisingly high percentage of the trees survive their rather rough-and-ready planting. Much depends, nevertheless, on the skill of the individual planter, and in getting the trees really firm in the ground.

The forester in charge of the work can influence its success to a marked degree by ensuring careful handling of the trees. As soon as they arrive, the bundles should be opened up and the tree roots "heeled-in" in a "bury" or shallow trench cut in the ground. Each planter should be equipped with a bag of sacking, carried on shoulder straps, to hold his stock of trees and protect them from cold drying winds. Attention to such technical points brings its reward in the form of even, well-established plantations.

But with the best of care some losses will still occur, and these seldom reveal themselves until the following summer. They are made good by the process of "beating-up" during the succeeding planting seasons. It is important to make good all losses as early as possible, or an uneven plantation will result.

OTHER METHODS OF AFFORESTATION

Besides the usual process of establishing plantations by planting transplants, there are other methods by which they can be formed, as detailed below:

PLANTING SEEDLINGS. Seedling trees are cheaply and quickly grown, but if planted out at that stage they suffer heavy losses except in the most favourable of seasons. Exceptions are the large seedlings of certain broadleaved trees, such as oak, beech, and sweet chestnut, which can be planted out successfully at the seedling stage if careful attention is given to their subsequent weeding.

DIRECT SOWING. In this method the nursery is dispensed with entirely. Seeds are sown in prepared patches out in the forest where the trees are to grow. But losses run high, and many seeds must be sown on each patch to allow for this. Weeding is difficult, and if many seedlings survive on each patch there is additional work in thinning them out. Also the seeds themselves have many enemies, such as voles and squirrels. So although it appears the most natural method, it is seldom followed in practice.

TRANSPLANTING NATURAL SEEDLINGS. This method, too, is rarely effective, as natural wild seedling trees seldom have the right root equipment to stand transplantation. And they are so costly to lift that it is almost as cheap to buy good nursery-raised transplants.

Two further methods can only be used for reafforestation, and then only when it is desired to continue with the existing tree species.

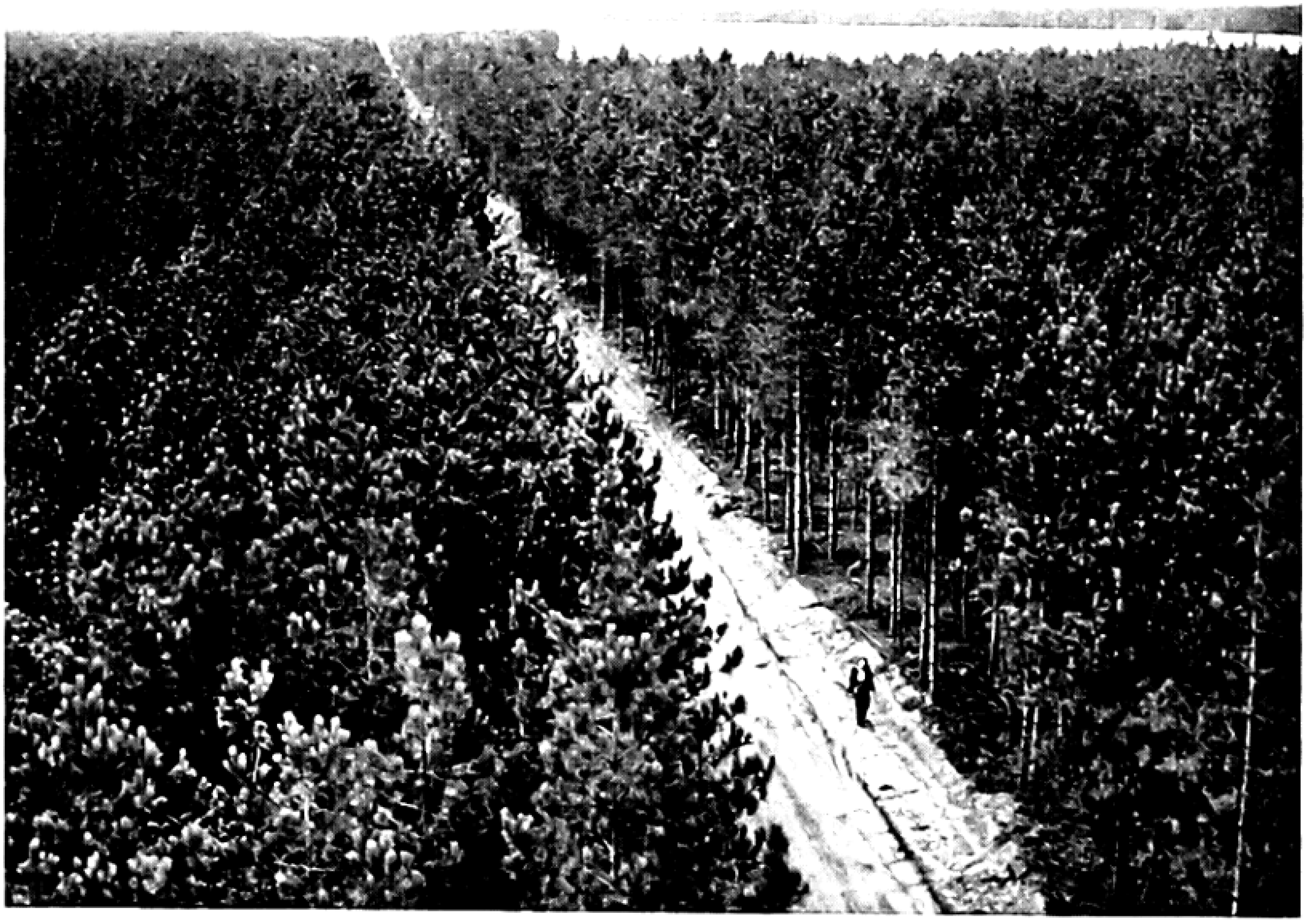
NATURAL REGENERATION. In this method the old wood is not entirely clear-felled, but a proportion of the old crop trees are left on a carefully considered spacing to form the "mother trees" for the next crop. The seed from these gradually replenishes the bare ground beneath them, and when the young crop has become established the "mothers" are gradually removed. In theory, every native tree, and some introduced ones, can be induced to regenerate its kind in this way. In practice the most successful of the native species are oak, ash, beech, and Scots pine. Amongst introduced trees, sycamore regenerates freely, as do some conifers, such as Douglas fir, the Silver firs, Maritime pine, Weymouth pine, and both the larches; spruce natural regeneration is sometimes seen, but seldom forms a crop. In expert hands, good results are obtained with selected species, but they are dependent on good seed years, the right soil conditions and ground covering, and variable factors of light, shade, and density of crops. Consequently the method is so far of limited application in Britain, though widely practised abroad (124, 125).

CONVERSION OF COPPICE. Broadleaved coppices may be converted to High Forest by thinning down each clump to a single pole, which is allowed to grow on to form a timber tree. Suitable species are ash, sweet chestnut, oak, and birch. This method saves the heavy costs of clearing coppices and replanting them. It is quick and cheap, though it does not yield the finest of timber. But it can only be used where a suitable distribution of coppice stools already exists on the ground. Hazel cannot be converted, and the standard trees grown amidst it are too widely espaced to provide shoots for future High Forests.

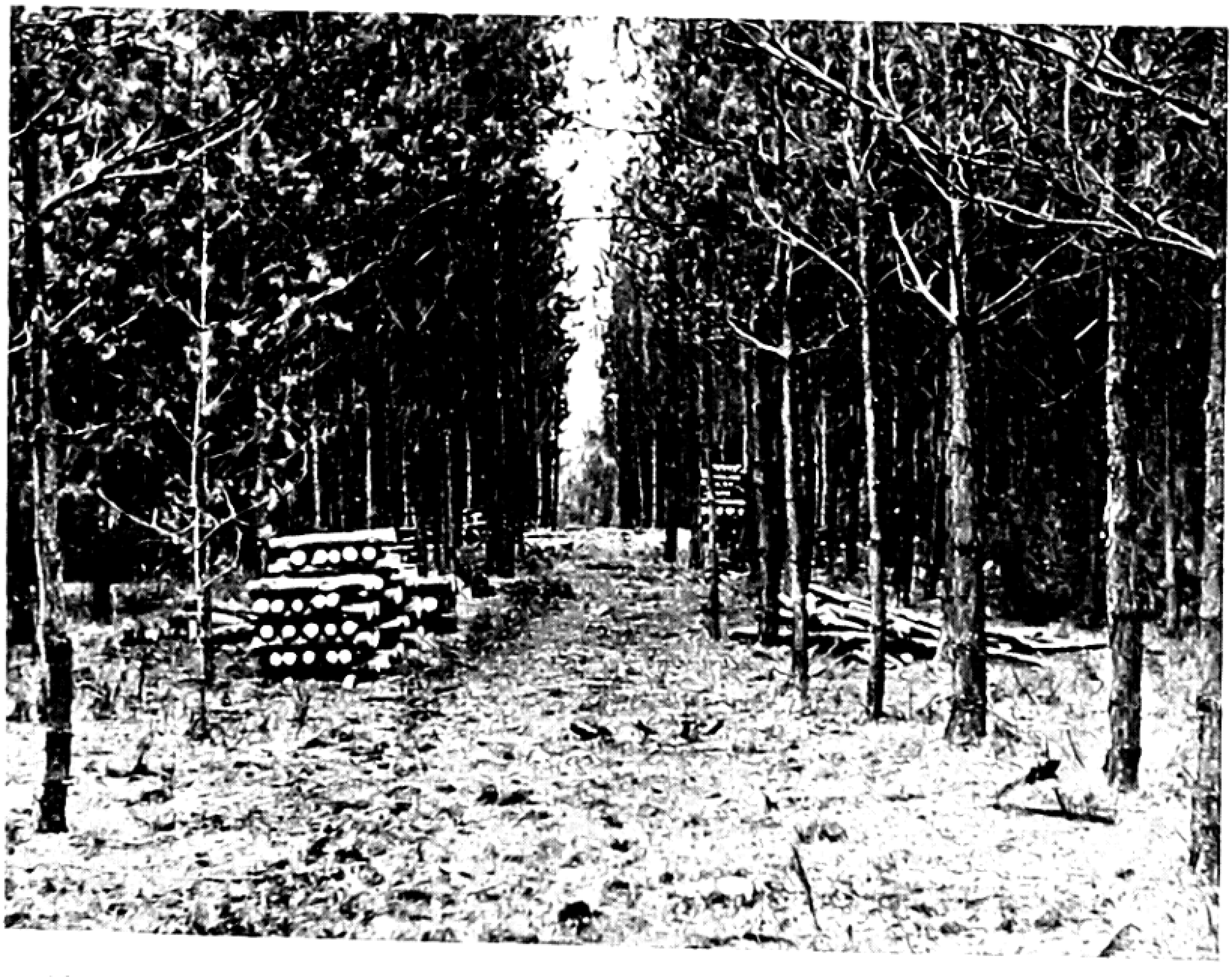
FORESTS AND THE LANDSCAPE

The planting of new forests works a slow but profound change in the scenery of their surroundings. Harsh outlines, especially in hilly country, tend to mar the beauty of the landscape, instead of enhancing it. It is nearly always necessary to plant trees in straight lines, but breaks between different kinds of tree may with advantage follow the natural features of the countryside, such as valleys, hills ridges, or contours. In coniferous forests, fringes of broad-leaved trees, including those with ornamental flowers or fruits, may be used as screens along roadsides. With careful planning, afforestation, which adds so much to the potential wealth of the countryside, may also increase its beauty and enrich its store of wild life.

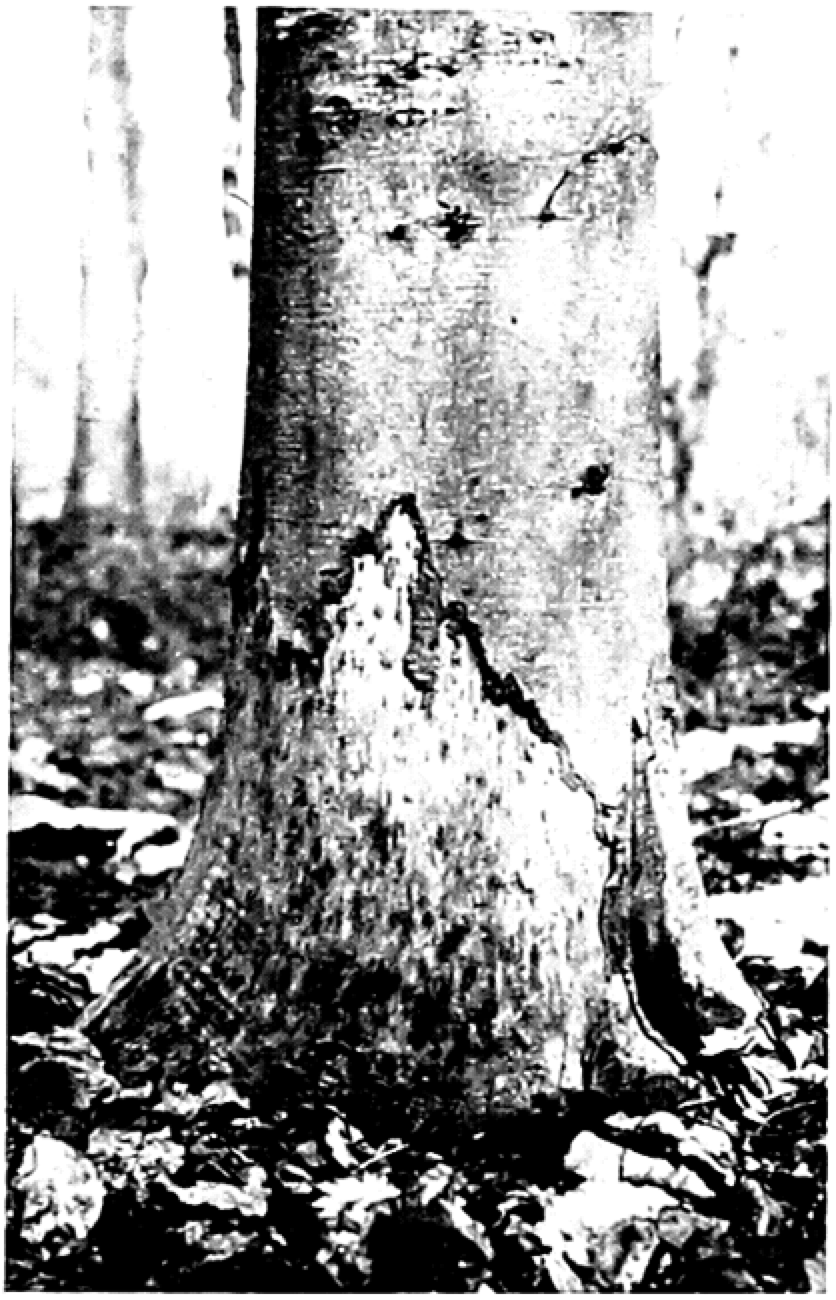
The planting up of large areas with conifers has aroused a certain amount of adverse criticism in certain districts. This is partly due to conservatism. People do not like to see changes in a familiar scene, whether they are due to the formation of a new wood, or the felling of an old one. British foresters, having to meet war-time demands and thereafter restore the country's reserve of growing timber, have had to make large clearances and replant extensively. Time will heal the old scars and mellow the new forests, until their beauty equals or excels that of those abroad.



134 A RIDE IN THE TWENTY-YEAR-OLD PINEWOODS OF THETFORD CHASE, NORFOLK, SEEN FROM A FIRE TOWER



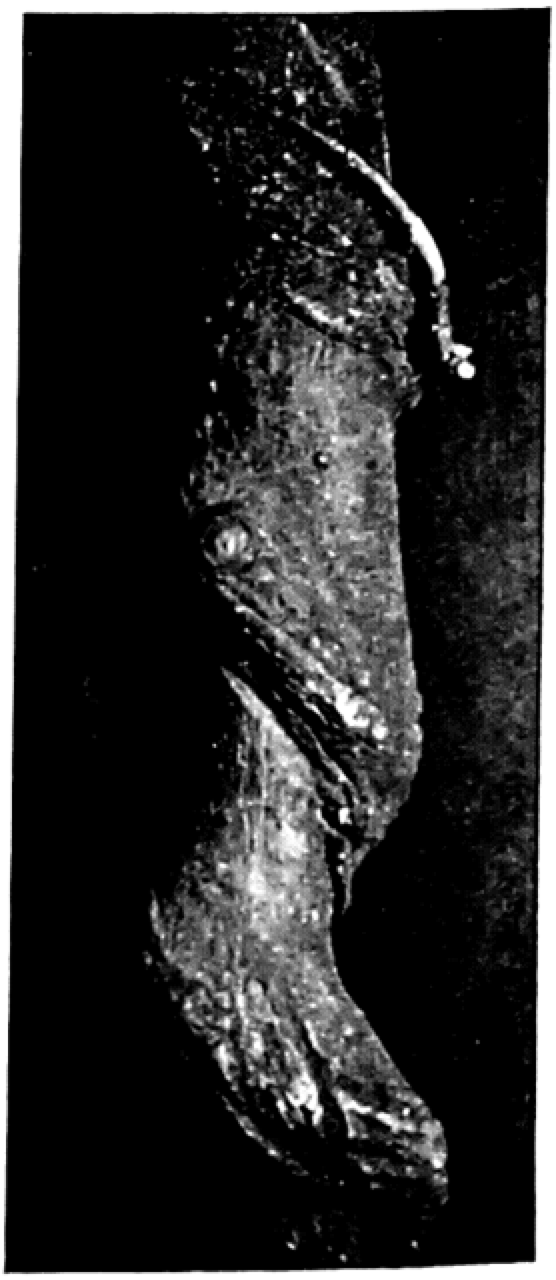
135 A RACKWAY THROUGH THE PINES OF BRAMSHILL FOREST, HAMPSHIRE, SHOWING PIT PROPS CUT FROM THINNINGS



136 BEECH BOLE BARKED BY RABBITS

137 YOUNG BEECH BARKED BY GREY SQUIRREL

138 DOUGLAS FIR BARKED BY DEER



139 STEM CONSTRICTED BY HONEYSUCKLE

FOUR FORMS OF DAMAGE TO FOREST TREES

CHAPTER 16

TENDING AND PROTECTING PLANTATIONS

Once a plantation has been formed, it requires continuous tending throughout its life until its final felling. In the early stages the frequent attention of the forester is required, and as a rule each tree must be freed from weeds for the first few years after planting.

Later the treatment becomes less intensive. Only a small proportion of the trees are removed when the all-important business of thinning first begins, and these thinnings, though repeated at intervals of a few years, become less and less frequent as time goes on. But all the time the plantation is kept under the watchful eye of the forester, who protects it against damage by fire, animals, or man. Thus the plantation is distinguished from the wildwood. Man controls its development at every stage, and finally ordains its end.

WEEDING

In their first few years after planting, young trees are very liable to be overpowered by the faster growth of other plants of many kinds. Each summer, therefore, they must be weeded. But the forester's weeding is a much less complete process than the gardener's. The competing plant growths are merely cut back with a curved reap-hook or similar tool, and it is seldom necessary to uproot them. At first weeding is usually done annually, or even two or three times in the same summer season ; but at length the young trees rise above the competing weed growth and finally suppress it with their shade.

The degree of weeding required varies widely from one place to another. On ploughed land no weeding may be needed, and the same is true of certain rocky slopes. In grass country, too, the conifers at least usually succeed in keeping ahead of their competitors. Bracken, however, is one of the worst of plantation weeds. It does little harm until the autumn, when its dead foliage falls as a dense mat, smothering the small trees beneath it. It must therefore be cut back, preferably at its young, green and tender stage, and as it is apt to shoot again it may be necessary to do this twice or more in one season.

Herbaceous plants such as foxglove and willow herb, both frequent on woodland soils, do little harm and are easily dealt with. But shrubs of all kinds present a more serious threat. One of the worst is gorse, not only a strong grower, spiny and difficult to eradicate, but also highly inflammable. Broom is also troublesome in some districts. Brambles give trouble owing to their quick-growing, long prickly stems. Other spiny shrubs are hawthorn, blackthorn, and wild rose. A long-handled tool called a " furze hook," with a curved blade (sometimes curved in two planes) is used to tackle such spiny vegetation.

On former broad-leaved woodland, some of the worst competitors with young trees arise from trees themselves. These are the coppice shoots thrown up from the stumps of the felled trees, with a vigour that varies with age and species. Younger trees of all kinds tend to coppice more vigorously than do old ones. Strong coppicers include Sweet chestnut, hazel, birch, alder, hornbeam, willow, and Field maple. Oak, ash, sycamore, Field elm, and the poplars coppice less vigorously, whilst beech and Wych elm usually throw only feeble coppice shoots. No coppice problem arises in new afforestation or in the replanting of former coniferous woods; but in hardwood areas, especially old hazel, chestnut, or hornbeam coppices, the work of weeding is often heavy. Though repeatedly cut back, the stool shoots persist in growing again. But frequent cutting lessens their vigour, and for that reason they are usually kept right down until the tree crop surpasses them and begins to close in above them.

THE THICKET STAGE

During their first year in the forest, trees normally make little growth, and are often described as being " in check." If all goes well, growth is resumed in the second season, and, provided weeds are never allowed to gain the upper hand, the young trees grow rapidly, gaining, as a general average figure, a foot in height each year ; some kinds, in favoured surroundings, grow much quicker. There is a corresponding increase in the spread of their side branches until in a few year's time these meet, interlace, and form a thicket.

Once trees are in the thicket stage, there is little that the forester can do to aid their growth, for the plantation is almost impenetrable. Such trees are normally from 6 to 15 feet in height, and from start to finish the thicket stage lasts from 5 to 10 years, varying with the vigour of the crop. Almost the only care that can be given is the protection of the vulnerable young crop against fire and animals such as rabbits and deer. Fire risk is at its height, especially in coniferous plantations.

By degrees the trees emerge from this thicket, for their upper branches overshadow their lower ones and the leafy canopy rises steadily upwards. The lower branches then die from lack of light, except on the outer edges of the wood, and as the density of their intermeshed network diminishes, the woodman is enabled to re-enter his plantation for the work of *cleaning* and *brashing*.

CLEANING. In many cases it will now be found that, despite every care in the earlier stages, weeds have grown up amongst the tree crop. Usually the only weed plants which survive the competition of the trees are shrubs, tree-weeds, or climbers. Amongst shrubs may be included the smaller tree species, such as hawthorn, blackthorn, crab-apple, privet, and wild rose, besides scramblers such as the brambles. The tree-weeds are either coppice shoots, or else trees of undesired species, such as birch, which though useful in their own sphere, may do more harm than good in plantations of other species. The principal climbers in Britain are ivy, traveller's joy, and honeysuckle; the last named can be very harmful, constricting the trunks of young trees into corkscrew-like contortions (57, 59, 139).

All such undesirable forms of plant life are removed in the cleaning. The slender-bladed reap-hook is now discarded in favour of the shorter, stouter, bill-hook or long-handled slasher, with which the woodman frees the trees of the true crop from encumbering vegetation of all kinds. Plantations on old woodland areas are apt to need the most cleaning; on new afforestation areas little or none may be required.

BRASHING. This process, frequently combined with cleaning, is only necessary in coniferous plantations. It consists in the removal, after the trees' canopy of foliage has risen to some ten feet clear of the ground, of the dead side branches that remain beneath it. Such branches have outlasted their usefulness. Left in the tree, they form *dead knots* which are a defect in the timber ; for the trunk, expanding, encloses each side branch as a slender cylinder running across its annual rings, and those that are dead before this occurs persist as a hard resistant core. If they are cut away, the outer, later-formed layers of the timber are knot-free or " clear."

Brashing has other advantages for the young crop. Fire risk is lessened, for the gap which is made between the ground and the canopy checks the advance of any blaze which may occur ; the dead branches which fall to the forest floor are inflammable for a season or two only, for they quickly decay. Thus they add to the humus of the forest soil. Access to the crop is made easier, which is an advantage for many purposes. The forester can move about freely to mark trees for thinnings, which can be cut down and carried out more readily by his labourers. The poles themselves are partially prepared for use by the removal of their lower side branches. Fires and vermin may also be tackled more easily.

The best tool for the work is a long-handled curved pruning saw, designed specially for this operation. If kept sharp and carefully set, this does very neat work. The side branches are severed as closely as possible to the main trunk, leaving no snags, and this induces the wounds to heal over quickly.

PRUNING. The removal of higher or living branches from a growing tree is termed pruning, and is sometimes required by both broadleaved and coniferous trees. It serves two objects, the improvement of the tree's form and the prevention of knotty timber. But trees competing with each other in a plantation or wood usually develop a good form of their own accord, and it is only exceptional cases that call for artificial aid. Such are those that form " twin leaders " or a forked main stem, when one stem may be cut away in order to favour the other. " High pruning " is occasionally carried out in good conifer stands. A worker ascends the tree to a height of 20 or 30 feet, and removes side branches all around the trunk with a hand pruning saw as he descends. This produces a long clean length of clear timber, but the process is only profitable if confined to those trees which are likely to form the main timber crop.

THE POLE STAGE

From ten to twenty years after planting, most plantations reach their pole stage, which lasts for fifty years or more until the stand matures as timber. At first the slender stems form a ranked parade of poles. Above, their crowns of foliage compete fiercely for light. Below ground, their roots engage in an equally intense struggle for soil nutrients. All kinds of weeds should now have been removed, and the forester's main duty is to control the competition amongst his trees by the all-important process of thinning (134, 135, 169).

THINNING. This is the key operation of the High Forest system. It regulates the growth of the plantation so that it not only gives a high volume and rapid growth of fine timber, but also yields valuable pole produce. Of the 1,750 trees originally planted on each acre, some 1,250 only are likely to survive to the start of the pole stage, as many succumb to weeds, pests, or diseases in their vulnerable early years. But only about 200 are required to stay the course to become timber. The balance of about 1,050 trees per acre are gradually removed at intervals as the growth of the crop makes it desirable. In this way the forester controls the course of life for each tree that lies in his care.

Natural woodlands are usually "uneven-aged." The competition between their component trees is tempered by their varying ages and sizes. But the "even-aged" High Forest produced by man's planting (or even by his so called "natural" regeneration of a previous crop) gives rise to a competition in which all the trees have a more or less equal start.

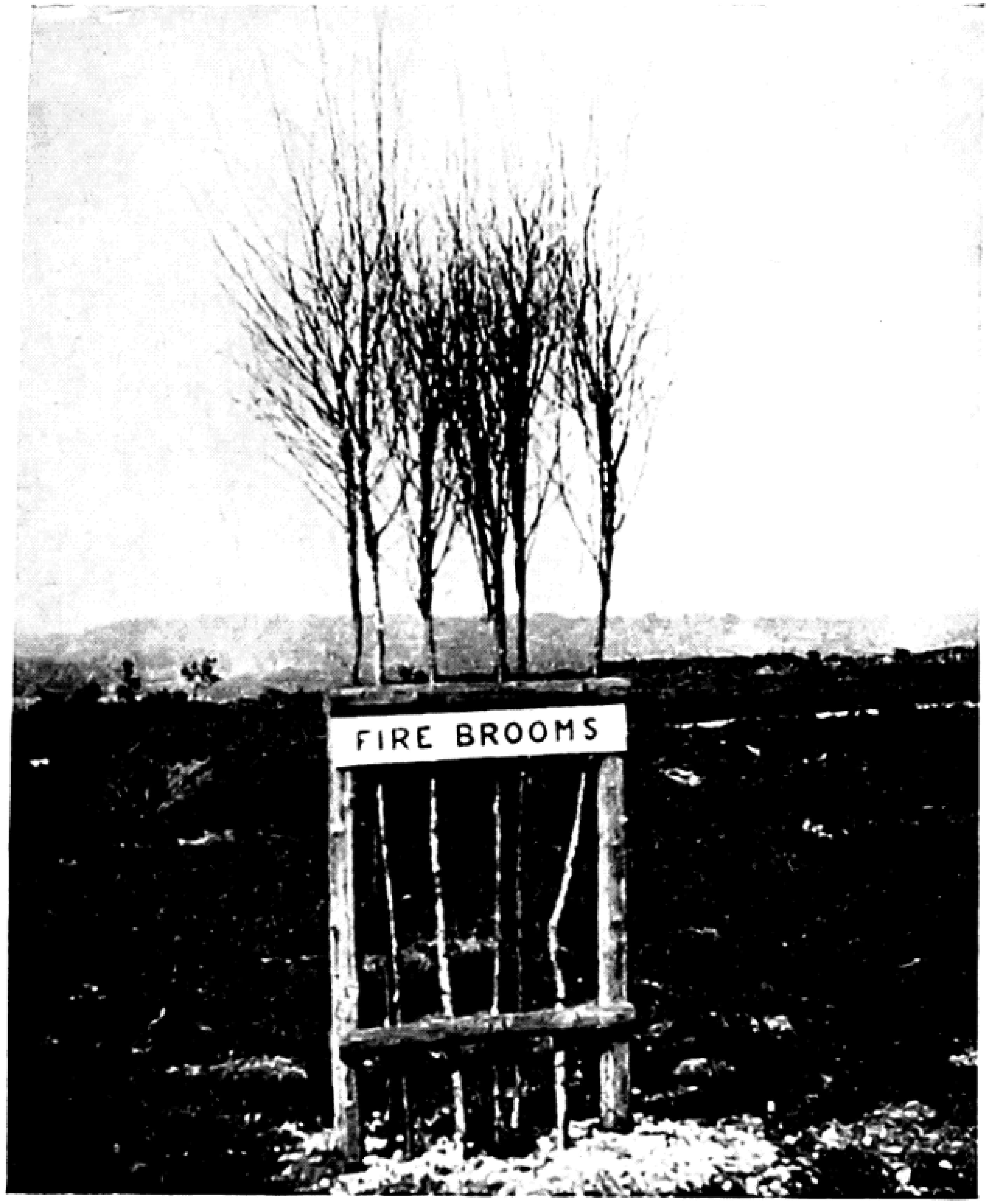
If such plantations are *not* thinned, the results are disastrous. Up and up go the young trees, crowded together so that their crowns of foliage cannot expand. Nor can their root systems spread freely. Inevitably their trunks do not expand normally, for they can obtain but little increase in nutriment, either from above or below, as they grow taller. Long spindly stems, lacking strength and stability, result. Then the first violent gale lays low the whole plantation.

By thinning, the forester induces the growth of well-balanced trees. He maintains the right number of stems on each acre of ground, having regard to their age, stage of growth, vigour, and species. Under this treatment, crowns and roots alike develop steadily, and those stems which are retained expand rapidly to give a large volume of valuable timber. The trees selected for removal are cut down and sold as poles, often at a profit. Thinning is so essential to the growth of good timber that it may have to be continued even when the cost cannot be recovered by the sale of the trees that are taken from the crop. There have been times when prices fell so low that the thinnings cut down were left to rot on the forest floor, but prudent foresters continued to thin in order to ensure the profitable growth of their final timber crop.

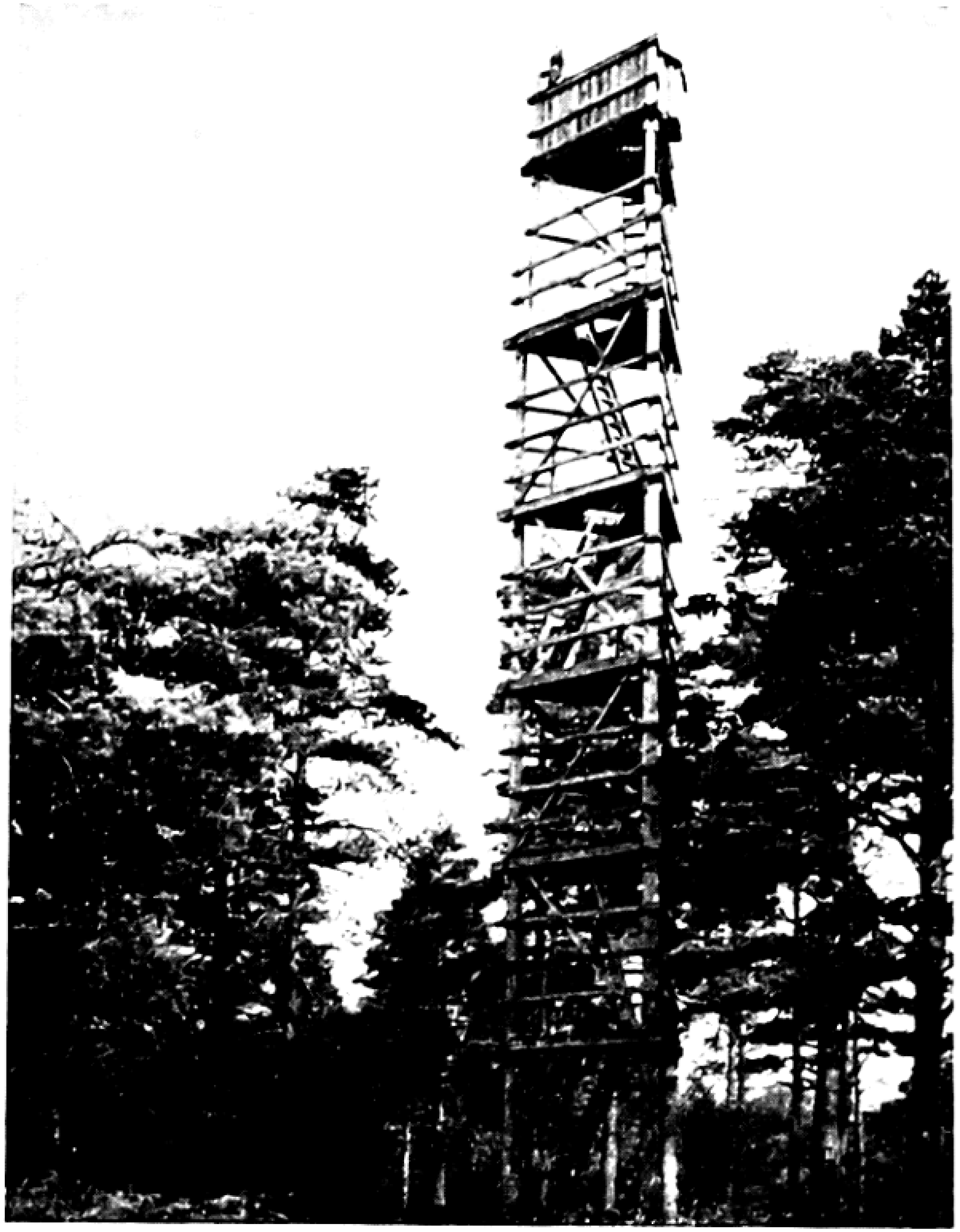
Thinnings are carried out at regular, but gradually lengthening, intervals. Thus, in a rapidly growing conifer plantation, they might be done at first triennially, e.g. in the 15th, 18th, 21st, 24th, 27th, and 30th years. Thereafter at five-yearly intervals, in the 35th, 40th, 45th, and 50th years. After that, once every ten years, at the 60th, 70th, and 80th years. After that final thinning, only the "final crop" trees would remain, to be felled at about their hundredth year. Thus the plantation might receive 13 thinnings and one final felling.

The number of trees removed per acre in each thinning gradually increases as time goes by. But there is no one ideal number to remove at each stage, and skilled foresters recognize different grades or intensities of thinning. It is the usual practise to thin some species, such as the larches, more severely than others.

Despite the decreasing numbers, the volume of timber left standing, and ts value, normally *increase* throughout the progress of the thinnings. The value of the trees removed in thinning normally rises also. The first thinnings may give only stakes and rails worth a few pence apiece, whilst the later ones may yield telegraph poles valued at a pound or more each. Naturally the final timber crop produces a timber volume greater than any thinning, and brings in the main financial yield of the plantation, but the thinnings, taken together, contribute a substantial share. As this monetary return begins to come in at an early stage, it adds appreciably to the profits that can be obtained by well-planned forestry.

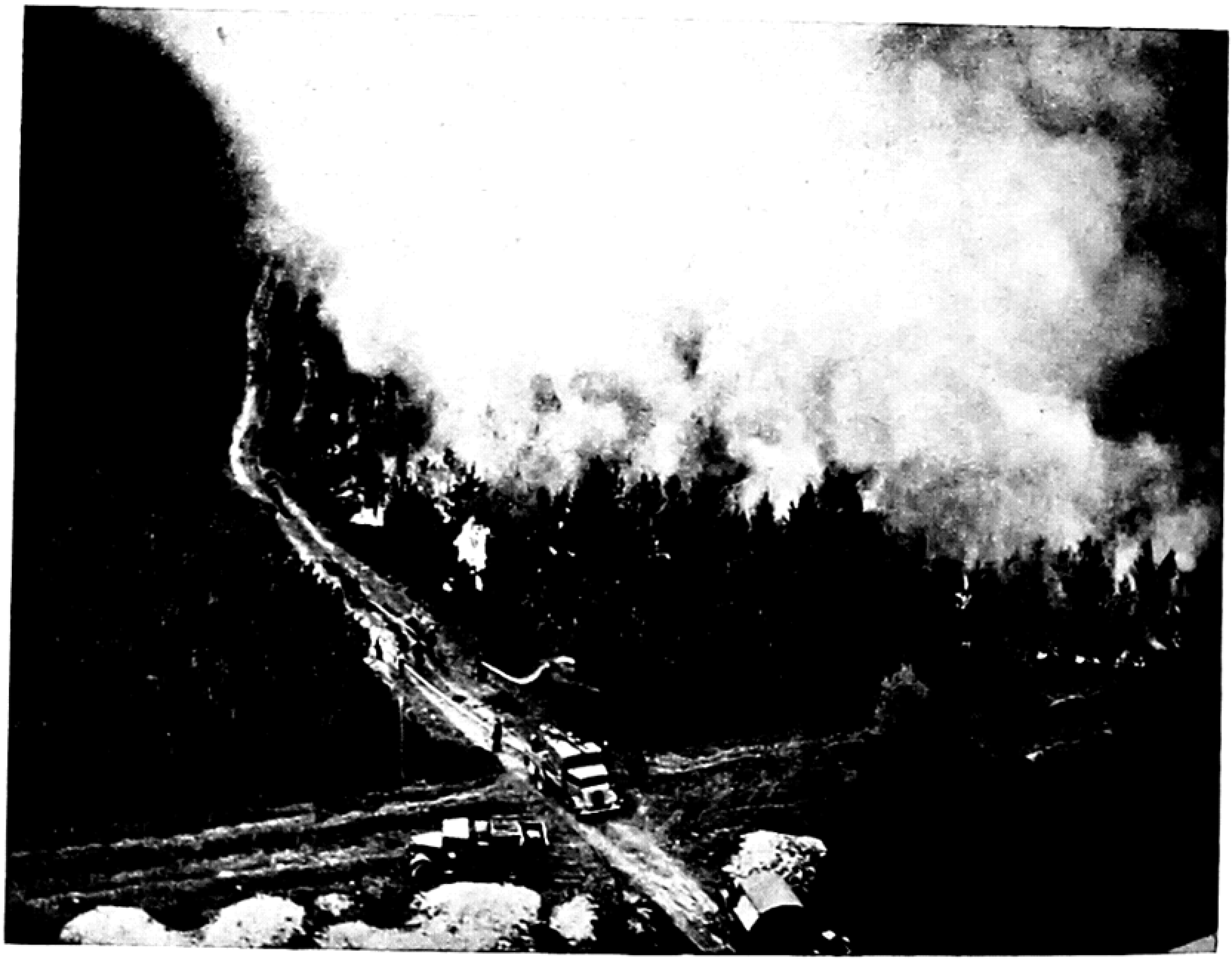


140 BIRCH BEATERS

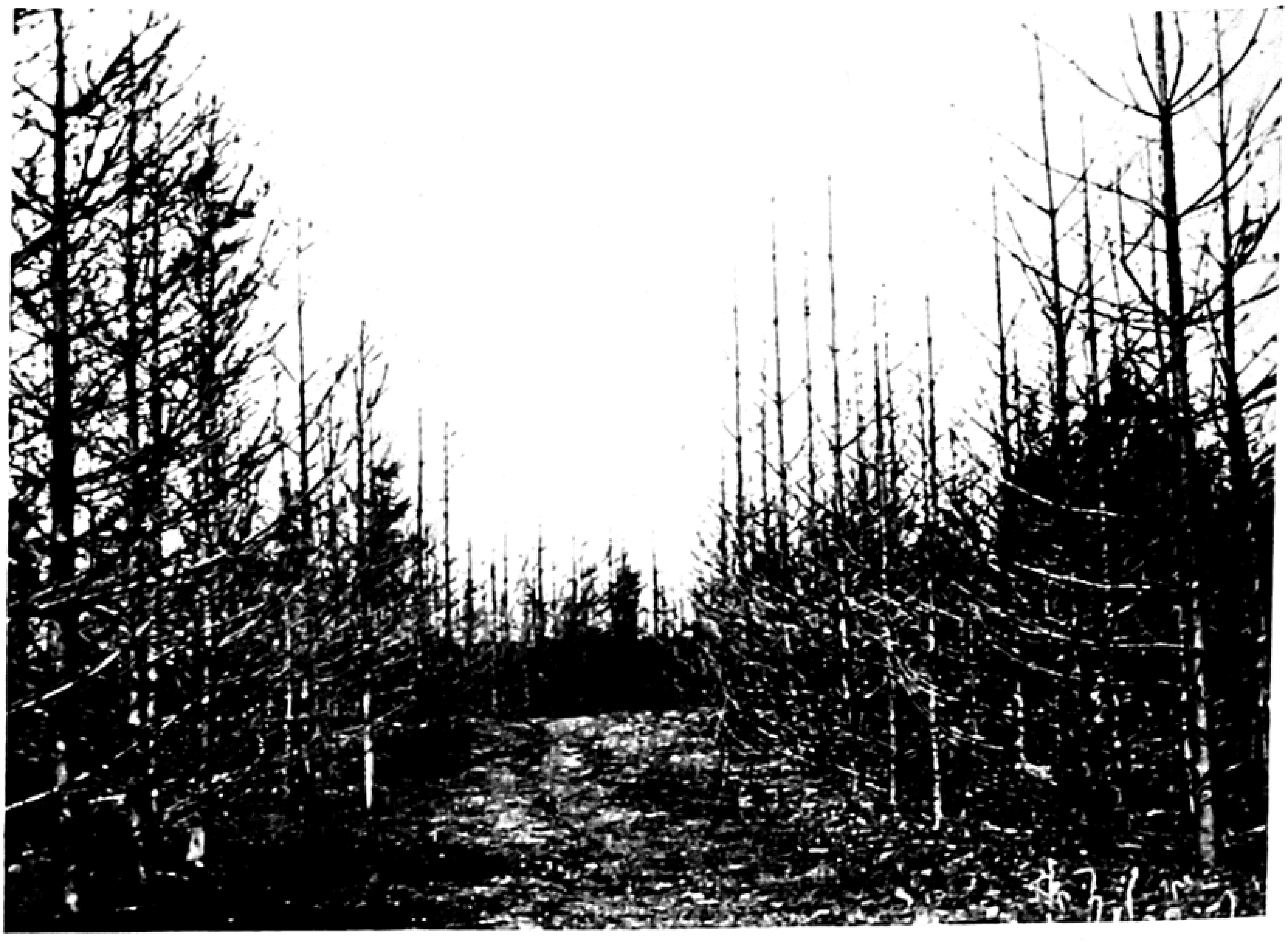


141 THE FRITHAM LOOK-OUT TOWER, SIXTY-FIVE FEET HIGH

FIRE PRECAUTIONS IN THE NEW FOREST



142 FIRE BRIGADES FIGHTING A FOREST FIRE NEAR BRANDON, SUFFOLK, MAY 23RD, 1946



143 A FIRE-SWEPT SECTION OF GWYDYR FOREST, CAERNARVONSHIRE

MARKING THINNINGS. The operation of thinning takes place in two stages. First comes the selection of the trees to be removed, and then their actual removal, conversion to useful products, and extraction from the wood; this latter process is dealt with in Chapters 17-19. Marking for thinning is work which demands a high degree of skill, for every plantation and indeed every individual tree, presents its own problems. Every tree must be inspected, its growth and its effect on its neighbours' growth considered, and a decision made. No tree may be removed, or permitted to remain, without forethought for its probable future.

So the forester moves about the wood, armed either with a paintbrush and paintpot, or a billhook for marking tree trunks with a " blaze " cut in their bark. Some trees cause him but little trouble. Obviously, all misshapen, bent, forked, diseased, or dying trees must come out as early as possible. So also must isolated specimens which have far outgrown their fellows, (known as " wolf " trees). Other cases are harder to decide. Straight, sound, and healthy trees may be marked for removal if they are being outgrown by the general level of the crop. These are the " suppressed " trees, and they are taken out at an early stage. If they were left, they would put on no useful increment in size themselves, and they might slow up the growth of others.

Marking thinnings is an art that can only be mastered by experience. All the while the marker must cast an eye upwards to the crown of the trees, deciding how far apart the remaining trees must stand to give them room for growth. Species, age, rate of growth, and intervals between successive thinnings, must all be borne in mind. The process is one that can never be reduced to mere routine. All the time the marker must consider closely the future of the remaining trees. Even though his thinned-out trees are bringing in a good return, he must assume that the final crop will be still more valuable. So the best and straightest trees remain, and the plantation acquires the statuesque beauty of tall-shafted columns as its timber matures.

Thinning is also an insurance against wind damage, for stout stems with good root systems are seldom either broken or uprooted. But care has to be taken not to thin too drastically at any one time, or sudden exposure may allow a gale to get a fatal grip upon trees not yet able to withstand it. Frequent, regular thinnings permit steady growth. This results in the annual rings of the wood being of even size year after year, which implies a steady increase in timber volume and value, and a high quality of even-grained timber.

THINNING MIXED WOODS. Where two or more kinds of trees are grown together, thinnings may be designed to favour one or another, or to preserve the balance between them. In the commonest form of mixture, one species is regarded as a " nurse " or auxiliary to the other, and is withdrawn at an early stage. For example, pine or larch planted as a nurse for oak, ash, or beech, might be removed in stages between the 20th and 50th years, leaving the broad-leaved crop to grow on to the timber stage. Conifers removed as poles give the earlier or " intermediate " return from the wood.

UNDERPLANTING. Sometimes an auxiliary species is added *after* the main crop is established, to preserve the soil fertility. The species which benefits most from this treatment is oak, and the underplants used are beech or shade-bearing conifers such as Norway spruce. Underplanted at about the 50th year, spaced between the taller oaks at the rate of some 500 plants per acre, these little trees thrive in its light shade, preserve the humus of the soil from too rapid decay, and suppress low side branches on the oak trunks ("epicormic branches"). This leads to better quality timber.

MATURITY

Even-aged woods gradually attain a state of development referred to by foresters as "maturity." That is to say, the crop as a whole reaches the maximum size or value that can be expected on its own particular site. When this point is reached is a matter for judgment tempered by experience. It varies with each species and locality. Approximate ages at which maturity is attained in Britain, are, for coniferous trees, 60 to 100 years ; for most broadleaved species, from 100 to 120 years ; and for oak, from 120 to 150 years.

Clearly, this is the best time for felling, for if the crop is retained beyond maturity, it soon ceases to show a profit on its planting and tending. It may, of course, be retained for sentimental reasons, but not for economic ones. On the other hand, if a crop is felled before maturity is attained, the best possible development of the timber, in size of stem and total volume, has not been reached. Therefore, although an earlier return is secured, the net profit is likely to be less than that of a mature crop.

PROTECTION

Plantations must be protected against adverse influences of many kinds throughout the whole of their course of life or "rotation." A hundred years is such a long time that much may happen that could not be foreseen by the first planters. But woods are altogether too large to be given the close care which is possible with garden plants. The forester's idea of protection is rather a ceaseless watch and ward so that the damage done by outside causes is kept down to a minimum by appropriate counter measures ; some losses must be faced, but if the bulk of the crop can be saved they are seldom disastrous. Laymen might easily be alarmed by the long catalogue of known forest plagues, pests, and diseases, but large-scale catastrophes are rare, and even so involve but a tiny fraction of the world's vast forest area.

PROTECTION AGAINST THE WEATHER. Physical damage to trees may result from winds, frost, snow, ice, hail, lightning and drought. All lie beyond man's power to control. But if foreseen their damage may be mitigated by the choice of resistant species for those sites where the harm that they do is likely to prove serious. Wind damage can be kept down in some measure by careful thinning, and by leaving windbreaks when the woods are felled.

Chemical damage due to natural causes occurs all around Britain's lengthy coastline, for in stormy springs salt-spray is blown inland and scorches young foliage of trees on seaward, windward slopes. But certain trees, such as sycamore and some of the pines, withstand its ill effects.

PROTECTION AGAINST FUNGI. The harmful fungi of the forest are very difficult to combat or control. The usual weapons of sprays and dusts are costly to apply in the woods, and not very effective or lasting in their effects. Diseased trees may be removed and burned, but on a large scale there are obvious limits to this procedure, apart from the difficulty of extracting every fragment of diseased roots or timber. Here again, correct choice of species at the outset will usually limit damage to the more backward trees of the plantations.

PROTECTION AGAINST INSECTS. The great size of trees and forests rules out most of the control methods for insect pests which are effective in gardens and orchards. Spraying, poisoning, and trapping are seldom of much avail. Instead the forester, aided by the expert knowledge of forest entomologists, seeks to control harmful insects by favouring their natural enemies, such as birds and predatory or parasitic insects. Another control measure is to remove breeding material such as felled timber before certain insects can complete their development in it (83).

PROTECTION AGAINST ANIMALS. Few wild animals are out-and-out pests of the woodlands. The worst is the rabbit, who must be destroyed, wherever he appears (136). Also harmful are the deer, and their numbers must be kept down to a low level (138). Squirrels, if too numerous, can do great harm to shoots, and branches by attacking their bark (137). All grazing and browsing domestic animals, such as cattle, horses, sheep, and goats, must be excluded from the woods. Besides the damage that they do with their teeth, they injure the forest soil by compacting it with their heavy tread. Sound fencing is the forester's greatest ally in this kind of protection, for it can be designed to keep out all kinds of stock, rabbits, and even deer.

PROTECTION AGAINST MAN. Woods have to be protected against many forms of human damage, such as theft and mutilation. Even the use of tree trunks as ready-made fence posts is harmful, for nails and wire persist in the stem which absorbs and grows over them. Years later, when the tree is felled, they may ruin the teeth of the circular saw that cuts it into planks. More remote human damage to forests arises from such causes as impeded drainage, due sometimes to subsidence following on mining, or chemical fumes from factories. Smoke renders the growing of conifers quite impossible in large industrial areas.

FIRE PROTECTION. The greatest cause of loss in forests, overshadowing all those mentioned above, is fire. Except for rare instances of lightning, all woodland fires are caused by human agency—a neglected match or cigarette end, a forgotten picnic fire, or a stray spark from a railway engine or road locomotive. They rarely, if ever, arise from the rays of the sun focused by broken glass, or through the spontaneous combustion of peat. Man-made fires are by far the most frequent generators of uncontrolled fire in the woods.

The degree of risk varies widely with different species of tree. Most broadleaved trees do not themselves burn, but all may be scorched to death in their younger stages, by the burning of other vegetation around them. Their roots are seldom killed outright, however, and coppice shoots may help to mend the crop. This is the case even with holly, the oily leaves of which burn like a torch.

Coniferous trees are, for the most part, inflammable (143). In their early stages, fire consumes them along with the surrounding vegetation. Later, in the thicket stage, the risk is at its peak. It is reduced by brashing, and gradually declines as the plantation ages and is opened up by thinning. Some conifers such as Japanese larch and Maritime pine, sometimes survive a fire.

Spring is the season of greatest fire danger, for then the woods and afforestation areas are strewn with the dry vegetation of the previous summer, especially bracken fronds and tussocks of grass. On the moors there may be heather, Purple Moor grass, and beds of peat. Spring droughts may coincide with strong winds, which aid and spread the blaze.

Forest fires do damage in proportion to the area that they involve. On a windy day they spread quickly and are hard to check. In still air, they are more easily tackled ; and if they cannot spread at all, they soon burn themselves out. Therefore fire protection measures are devoted in part to locating the fire before it grows big, and partly to stopping its spread.

The first object is achieved by a vigilant watch, involving the stationing of patrols at danger points in dry weather, and co-operation with residents in the area so that any suspected fire is promptly reported to the forester, preferably by telephone. The second object is attained in two ways, by advance preparation and direct action. The advance preparations are commenced well ahead, often years before the risk becomes acute. Direct action only begins when a fire actually breaks out, but this too requires forethought.

ADVANCE PREPARATION aims at creating a set of circumstances which will impede the spread of a fire over large areas. Thus, it may be obliged to die out through lack of more material within reach of its burning, or it may be easily overcome by active fire fighters, or both these factors may lead to its subjection. Advance measures to check fires include the provision of fire-breaks across the plantations, dividing them into blocks by roads, rides 30 feet or more wide, and belts of uninflammable trees. Natural obstacles such as streams, lakes, rock faces, or stretches of marsh, etc., may be keyed into the artificial firebreaks. Rides may be rendered even more impassable by ploughing up, or bulldozing; and the ploughing of the actual planting area also reduces risks for some years. Brashing lessens risks in young coniferous plantations. The avoidance of large blocks of trees all of the same age is also a helpful factor.

All these precautions help to reduce the area of woods that is likely to be involved in a single outbreak of fire. Another useful advance measure is the provision of ample means of access so that when a fire does occur, men can reach it before it has time to spread. Ploughed firebreaks, if harrowed down to give a smooth surface, are passable by cars and lorries in the dry weather which renders fires most frequent. Emergency water supplies may also be arranged well in advance of the actual need, and fire brooms provided (140).

ACTIVE FIRE FIGHTING begins once an outbreak is seen and reported. The main methods used are beating the face of the fire with fire brooms or shovels, and watering with power pumps, hand pumps or even buckets. A gang of men working together can do a great deal with these simple methods, but if the blaze is clearly beyond their control by direct attack, they may still be able to check it by *counter-firing*. This means the lighting of a smaller, controlled fire in the path of the main one, preferably along the edge of a ride or similar firebreak. This burns slowly towards the main fire, until the two meet and coalesce, forming a burnt strip which the main fire cannot cross. Other methods which may sometimes have to be employed include the cutting of improvised firebreaks in the form of gaps across the burning plantation, the digging of trenches to stop fires in the ground spreading through smouldering peat, and the ploughing or bulldozing of a fire-proof strip across the fire's probable path. The last two methods are effective safeguards when a fire burns deeply into surface peat ; peat fires may flare up again at any time whilst dry weather continues, and so call for constant care and watchfulness.

The sooner a fire is attacked, the greater the chance of checking it with a few men. Half a dozen willing hands can deal with a blaze which, if left for half an hour, may have spread beyond the scope of a hundred. If the advance fire precautions are well planned, the active measures key in with them. For example, a fire may be trapped within a corner of a block formed by barriers of various kinds, or motor-borne power pumps may speed along good forest roads to well-sited water supplies (142).

The risk of loss by fire must be faced whenever a plantation is made. Fortunately, it is seldom a great risk when the total area of a wooded estate is considered, and it may be insured against at a reasonable premium.

Where forests cover an area sufficiently great to make the outlay worth while, towers may be erected at high points, from which a look-out man may survey the whole expanse (141). These are manned in dry weather, and as a rule their equipment includes a map, and a fixed table marked with bearings to serve as a direction indicator. The complete circle around the tower is divided into 360 degrees, the north point being at the 360 mark, east at 90 degrees, south at 180 degrees, and west at 270. This enables the direction of any fire sighted to be compared with the map, on which the position of the tower and the bearings from it have been previously marked. Further, this information can be telephoned to a central control room and checked against other reports. If two or more look-outs report the same fire, the point at which their respective bearings intersect will fix its position with great accuracy, enabling fire-fighters to be despatched without delay.

CHAPTER 17

TREE FELLING AND TIMBER TRANSPORT

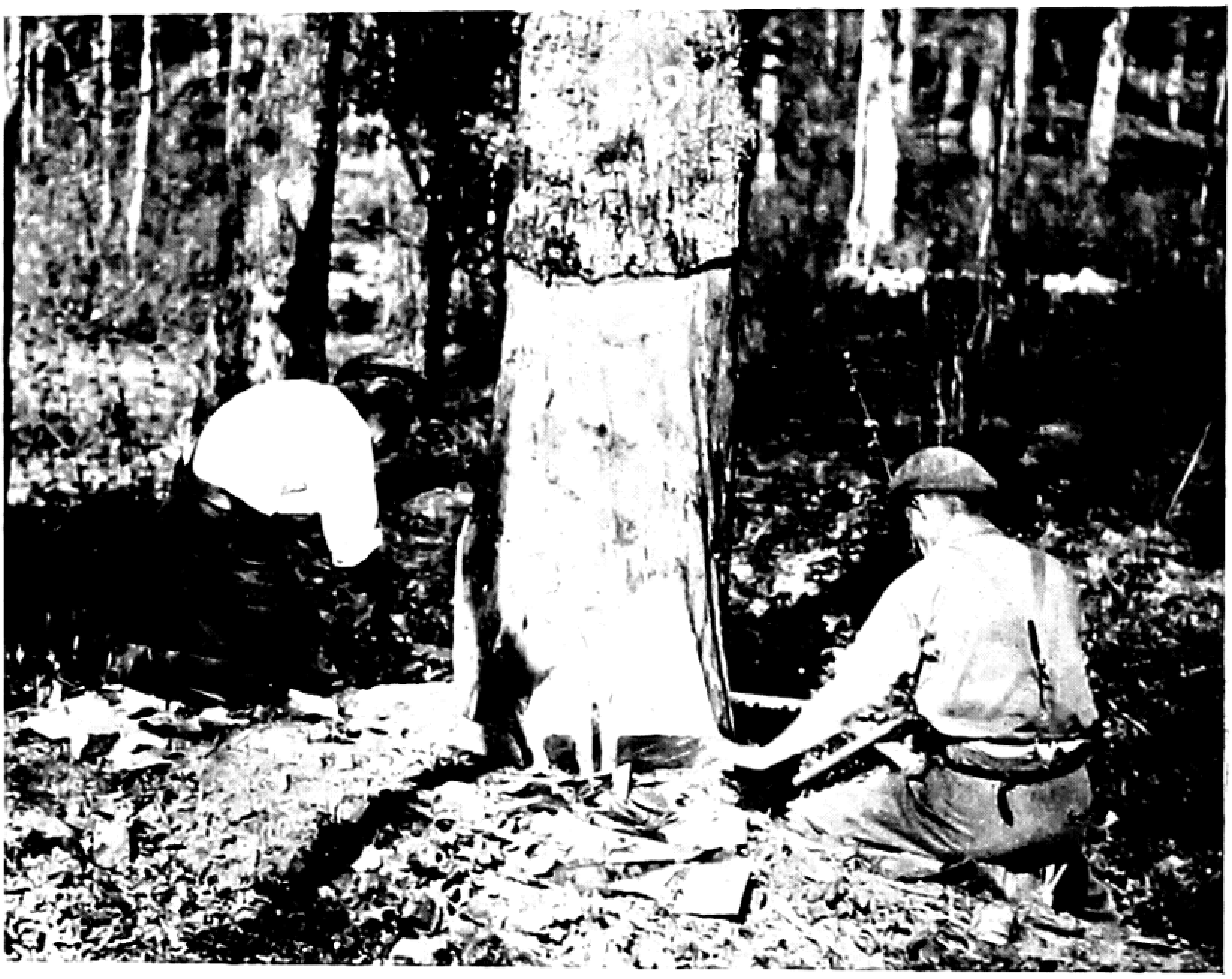
The preceding three chapters relate to the growing of timber from the seed to the mature crop. But the forester's skill must range further, to include its profitable conversion from the standing tree to the trimmed log delivered to the sawmill, mine, or factory. Big timber is often sold as it stands to merchants who undertake this work, but even so the forester has to understand it thoroughly in order to regulate their activities in the woods that lie in his care. The operations of felling and hauling out add substantially to the commercial value of the timber ; and its sale price, when prepared and carried to the nearest station, may be double what it was when it stood in the forest as a growing tree.

FELLING AND TRIMMING

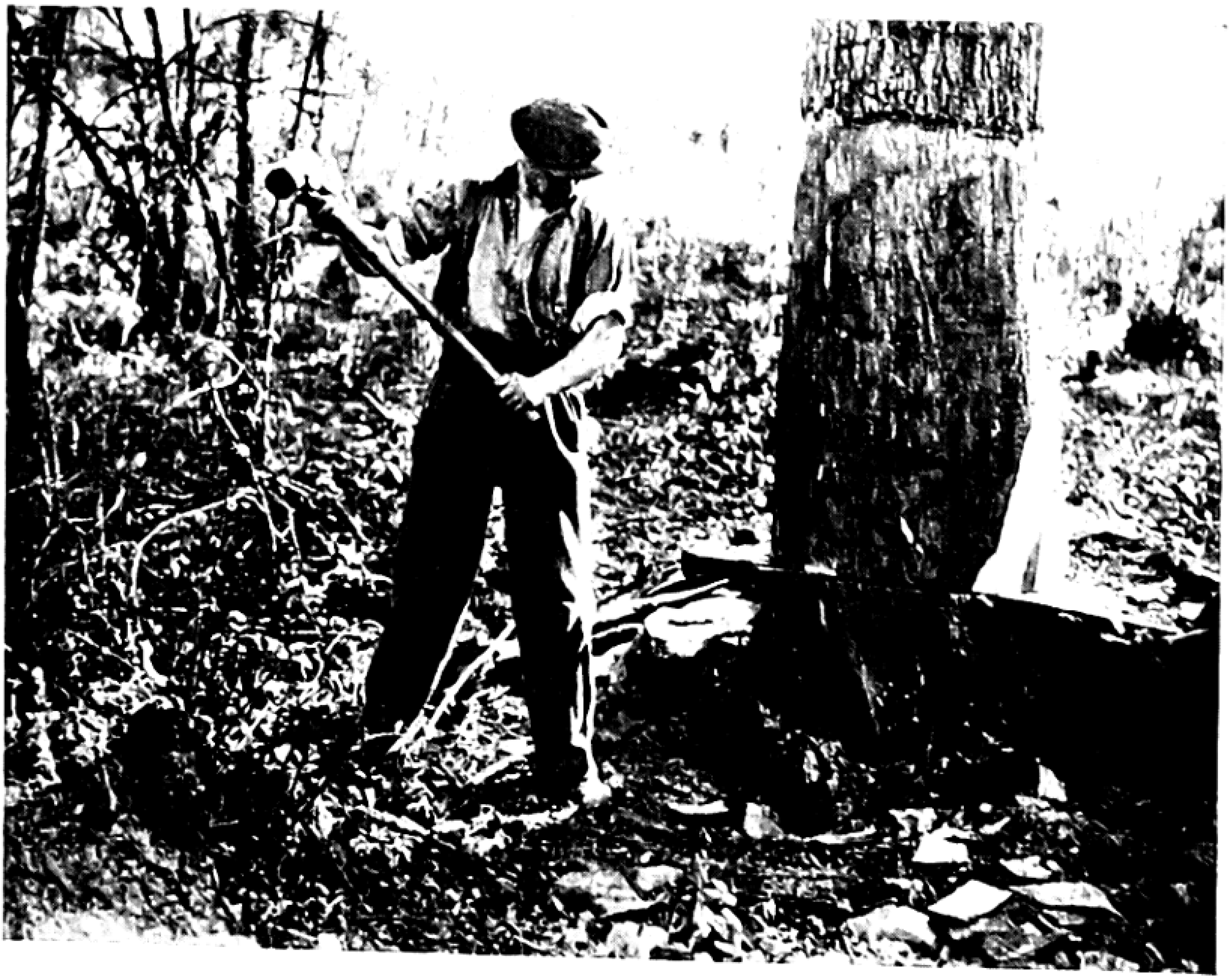
FELLING. Young trees or saplings are easily cut out with the bill-hook, hatchet, hand-axe, or bow saw, or some combination of these tools. For the felling of larger timber, felling axes, felling saws and steel wedges are necessary equipment. Felling saws require two men for their use, and tree-fellers therefore work in pairs. Each pair is generally paid by results according to the volume of timber which they bring down.

The procedure may be outlined as follows : The tree is first of all " laid-in " with the axe ; that is to say, a ledge is cut in the trunk, just above ground level, by a series of vertical and horizontal cuts with the axe-blade. This ledge may extend right around the tree, or be varied in order to influence its fall. Then the saw is set to work horizontally on this ledge to cut through the trunk until the tree falls. The cut is started on the side opposite to that in which the tree is expected to fall. The gap in which the saw works is kept open by using wedges, which are driven in with a sledgehammer. This prevents the sawblade from becoming pinched or trapped, and also tilts the tree trunk very slightly in the desired direction (144, 145).

THE FELLING AXE. This familiar tool has as a rule a single cutting face and a flat back ; double-bladed or " two-bitted " axes are rarely used in Britain. The handle, of ash or hickory wood, is some three feet long and generally curved ; straight handles are seldom seen. The metal head is of tempered steel either solid or built up around an iron base ; wedge-shaped, it tapers from a flat and parallel-sided back to a fine edge. This edge is not straight, but slightly convex. An infinite variety of felling axes are employed in different parts of the world, each having minor advantages for its own particular work. All, however, depend for their effect on three factors—weight, speed, and the keenness of their cutting edge. The best weight to use is decided by the individual strength and skill of the tree-feller ; a weight of five to six pounds for the head is a usual figure. The sharpness of the edge is retained by the use of a rotary grindstone, aided by frequent applications of a small round " axe-stone." Keeping his axe in working trim is a matter of pride with a keen feller ; indeed the axe is such a personal tool that many men prefer to provide their own.

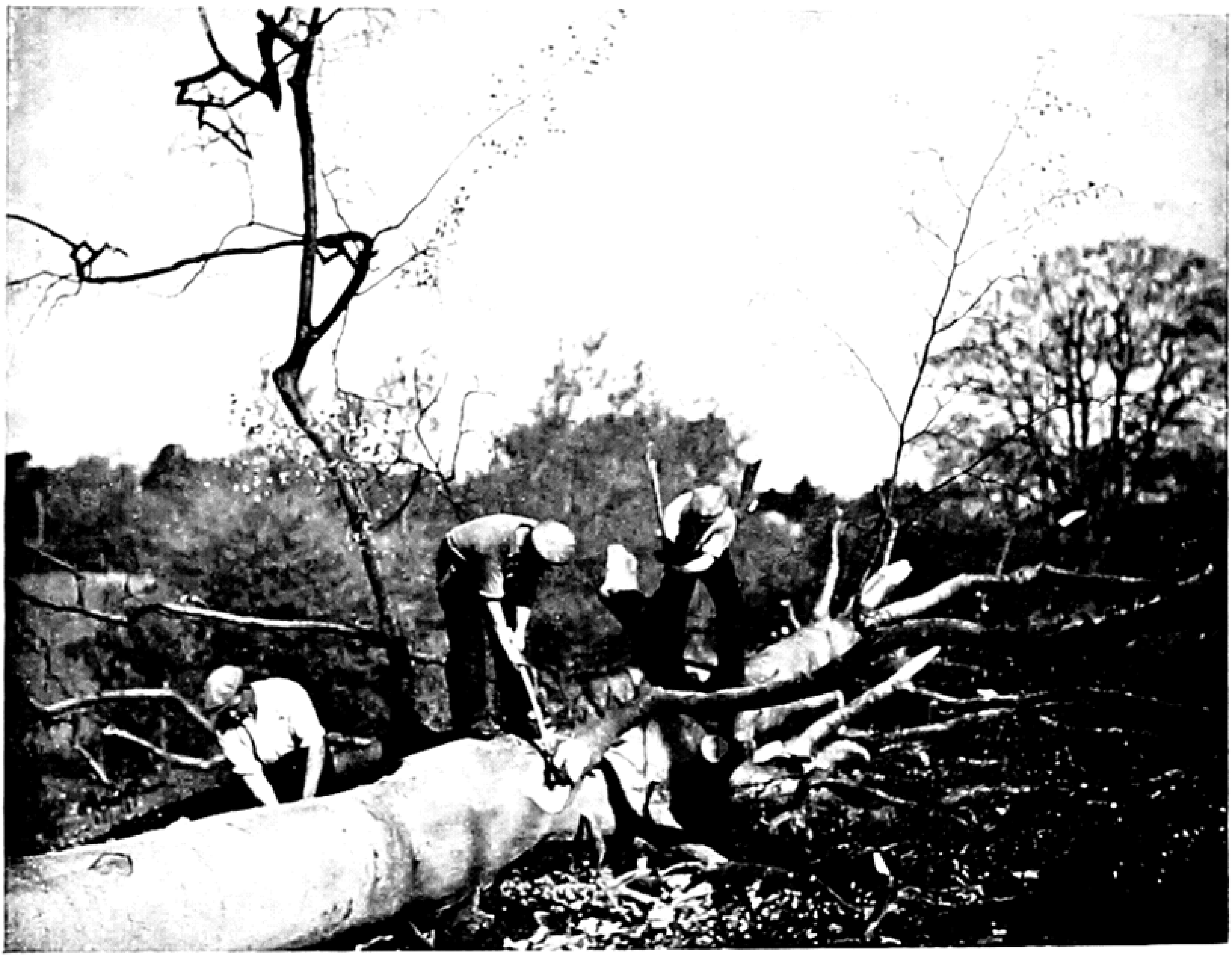


144 CUTTING WITH THE FELLING SAW, TOWARDS THE ORIGINAL AXE-CUT

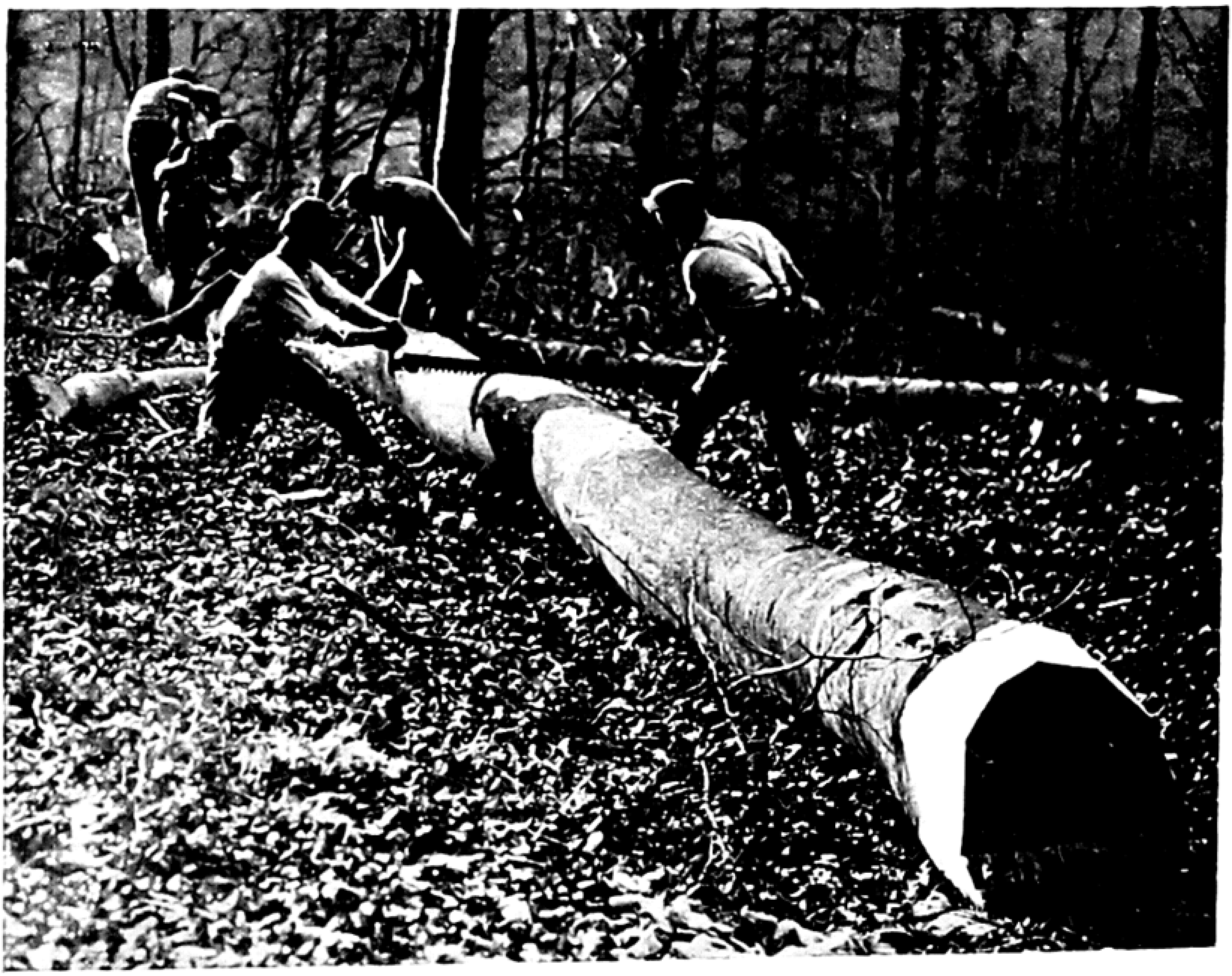


145 DRIVING WEDGES TO KEEP THE TREE'S WEIGHT OFF THE SAW.

TREE FELLERS AT WORK



146 TRIMMING OUT A BEECH BOLE



147 CROSS-CUTTING THE TRIMMED BOLE

Smiting with an axe is one of those fundamental actions, like walking, which are more easily learned than described. Briefly, the axe is a "missile tool," and does its job by virtue of its combined speed and weight, or *momentum*. This momentum is imparted to it by the feller's right hand and arm. His left hand, resting at the foot of the handle, serves mainly to guide the moving head and steady the blow. (The two hands may be changed about, if so required.)

At the start of the stroke, the right hand is near the upper end of the handle. As the head is directed at the tree-trunk, this right hand drops almost automatically to the lower end. That is the secret of speeding the axe. At first the head is *thrown* by the right hand ; later in the same stroke it is *whirled* for the fraction of a second before it strikes.

When tree felling, the axe handle should never be held rigidly by both hands. This pose is sometimes adopted by beginners, or sketched by artists, with ludicrous results.

AXE STROKES. Two main strokes are used in tree felling. The first stroke of each cut is made downwards, and so splits off a wedge-shaped chip of wood. The next is horizontal, and so completes the cut by severing the chip at the base. Each is repeated or varied as occasion requires, the object being to create a wedge-shaped gap with inclined sides and a level base. Obviously, if the process is continued, the tree will fall, but felling with the axe *alone* is rarely practised in Britain. It is slow, laborious, and costly, for it wastes a great deal of valuable timber in the form of chippings. Therefore the saw is brought in to do the bulk of the cutting.

THE FELLING SAW. This is a special saw adapted to tree-felling, consisting of a blade of tempered steel with detachable handles. These handles are so arranged that they can be used in either a horizontal or vertical position, whilst the blade cuts through the tree horizontally. To obtain the largest output of timber, the cut should be made as close to the ground level as possible. In outline, the blade of a felling saw should be "flat-backed" or "hollow-backed" ; that is with a convex face and a flat or *concave* back. The "fish-backed" saws used in cross-cutting, which have both face and back convex, are of little use for felling, as they do not permit of the insertion of wedges in the saw cut behind the blade.

Saw teeth are made in various patterns by different makers. A common pattern has them set in groups of four. Two of each group face one way, two another; each is sharpened so as to cut in both directions of the stroke. A wide gap, to accommodate sawdust, lies between each group. In this stands a "clearer," a tooth whose job it is to clear out sawdust rather than to cut the wood itself. It is essential to remove this sawdust as the blade speeds through the cut, as otherwise it would clog the cutting face.

The saw is kept in working trim by the use of a file and a "saw-set." The former restores the edge of the numerous teeth, whilst the latter is used to maintain the "set" or deviation of the tooth-points from the plane of the blade. Saws require oiling when in use. Blades are made in varying lengths according to the diameter of the trees to be felled ; five feet is ample for the normal run of timber.

WEDGES. These are used behind the saw to keep open the saw-cut and prevent pinching; also to throw the tree in the direction required. They are made in sets of varying sizes and are sold by weight.

FELLING DIFFICULT AND DANGEROUS TREES. The tools described above are sufficient for straightforward work, where a variation in the direction taken by the tree is unlikely to have serious results. But often enough a tree must be felled in one pre-determined direction, to avoid buildings, walls, telephone wires, or other trees. As like as not, it is leaning in another direction, so special measures must be taken to cause it to fall in the right path.

ROPES AND PULLEY BLOCKS. By itself, a rope is of little assistance, as if anchored to a fixed point the strain on it cannot be adjusted; but if it is led to a pulley block the tension can be altered as required, and the tree's fall guided accordingly.

MONKEY WINCHES. These ingenious devices are attached to the base of a neighbouring tree, or some similar holdfast. A wire hawser is then led from them to the trunk of the tree which it is desired to fell, and secured some distance up from the ground. The tension on this hawser is increased by a simple leverage device, worked by hand. Enormous force can be exerted, and the tree is easily persuaded to move in the right direction. So powerful is this winch that it will readily uproot quite large trees.

MONKEY JACKS. For rope or winch mechanisms, some form of anchorage is essential ; moreover, this must lie in a certain direction relative to the falling line of the tree. But the monkey jack does not need an anchorage, for it pushes the tree instead of pulling it. Its base presses against the ground and its top keys into a notch cut for it in the tree-trunk. Worked on the principle of a motor car jack, it pushes the tree away towards the opposite side, and so over.

TRACTORS AND TRACTOR WINCHES. A tractor, equipped with " spade lugs " on its wheels, is effective for guiding the fall of small trees, especially if working on a rope which is led through a snatch block pulley. More effective still are tractors equipped with winches driven by the power of their engines. These have an anchoring device which fixes them firmly to the ground, and enables them to exert a steady pull to govern the fall of the tree.

THE FELLER'S CRAFT. Words can scarcely convey the degree of skill which an experienced woodman brings to the task of tree-felling. His eye takes in a number of factors at a glance—the kind of tree, the slope of the ground, the way and the force of the wind, how the tree leans, how its weight lies, and the nature of its surroundings. Summing these up, he and his mate set to work. The ring of the axe, the hiss of the saw, and the staccato blows of sledge-hammer on wedges, are followed by the rending sound of the falling trunk, and the loud crash as its head of branchwood strikes the earth. They must fell the tree without damage to its timber or to surrounding trees in the falling, and without waste of timber in the stump. Should a tree " hang up " by becoming lodged in the branches of a neighbouring tree, hours of dangerous labour will be their lot until they have freed it.

British tree-fellers are amongst the most skilful in the world. In other countries where timber is cheaper and more plentiful, waste which would never be tolerated here is a common occurrence in the interests of speedy production. For example, in North America trees are often felled a foot or more above ground level, so wasting the timber in the high stump. In Britain, the cut is made at ground level, a more skilful and arduous process. Tree felling demands strong physique, and mechanical saws have so far failed to displace man's muscular power to any degree. It is hard and exacting work, but exertion is encouraged by the payment of piece-work rates, which are usual in this trade.

TRIMMING FELLED TIMBER. Once the tree is down the fellers proceed to trim out the trunk with their axes and saws (146). Frequently a lighter axe is used for this work. The top of the tree is cut away at the point beyond which it is unlikely to provide timber, known as " timber point." In the case of conifers, the tree top beyond this point is often suitable for cutting into pit props ; but with the broadleaved trees it seldom provides anything except " cordwood." Cordwood is the substance of the irregular branches, so called because it is stacked for measurement and sale in units called " cords." Each cord is usually 8 feet long, 4 feet high, and 4 feet through ; dimensions vary in different parts of the country, but the superficial volume of a cord is usually 128 cubic feet. Actually it contains much less wood, owing to the large amount of air space. Cords are sold for firewood, pulpwood, or charcoal burning. Side branches and topwood too small for cording are piled and burned to clear the ground for the succeeding tree crop.

MEASURING-UP AND CROSS-CUTTING. After the removal of the branches, the main trunk and limbs remain. These are measured by the timber merchant, forester, or other person in charge, to ascertain their timber volume. The length of each piece is measured in feet, and its girth at the mid-point in inches, and from these two figures, its volume in " Hoppus " cubic feet can be calculated by means of tables. This measure is taken at an early stage, for the fellers are paid so much for each cubic foot of timber volume in the trees they have felled; the bigger the tree, the more their pay. (See Chapter 20).

" Felled measure " is also widely used as the basis for the sale of timber. Consequently a representative of the seller frequently accompanies the purchaser or his representative in order to check the measurement, and both parties keep a record of the figures. The measured logs are then numbered for reference. They may next be cross-cut with saws into lengths convenient for hauling out from the wood, but when modern tackle is to be used they are usually left in the greatest length possible (147, 165).

TIMBER TRANSPORT

TUSHING. The first stage in the transport of the fallen tree from forest to mill is termed " tushing." A chain is fixed around its larger or " butt " end, with a spike driven in if required to give a better grip. Then the log is hauled butt-end foremost, with the length lying on the ground, out through the wood to a point where it may be loaded on to a timber carriage. Horses are still occasionally used for tushing, and have the great merit of doing little or no damage to the surrounding trees, whereas tractors are apt to bark them with their tracks or ropes.

But tractors are now the general rule. Wheeled tractors with spade lugs handle small timber well on easy ground. For big stuff, or on rough, broken, steep, or marshy ground, tracked tractors are preferable.

TRACTOR WINCHES are the latest development. These carry a drum driven by a power take-off, over which a wire rope is wound. By remaining stationary, and using all their engine power to wind in the rope, they can exert greater power than they could do by direct pulling, even in low gear. An anchor bar let down into the ground, keeps the tractor itself stationary, so that the log is drawn towards it. If necessary, when the log has been drawn so far, the tractor can pay out the rope again as it travels to a new hauling position. These winches are of great value when heavy logs have to be extracted uphill, and represent a useful reserve of power for all difficult hauls.

To ease the strain of tushing, and to prevent damage to forest rides or tracks, *timber-bobs*, known also as " big wheels " and " sulkys, " of various designs are sometimes used. These consist of a pair of wheels or " bogey," which supports the log either at one end or at the centre. They may be used with either horses or tractors, and for the heaviest logs a type which runs on tracks has been devised (148).

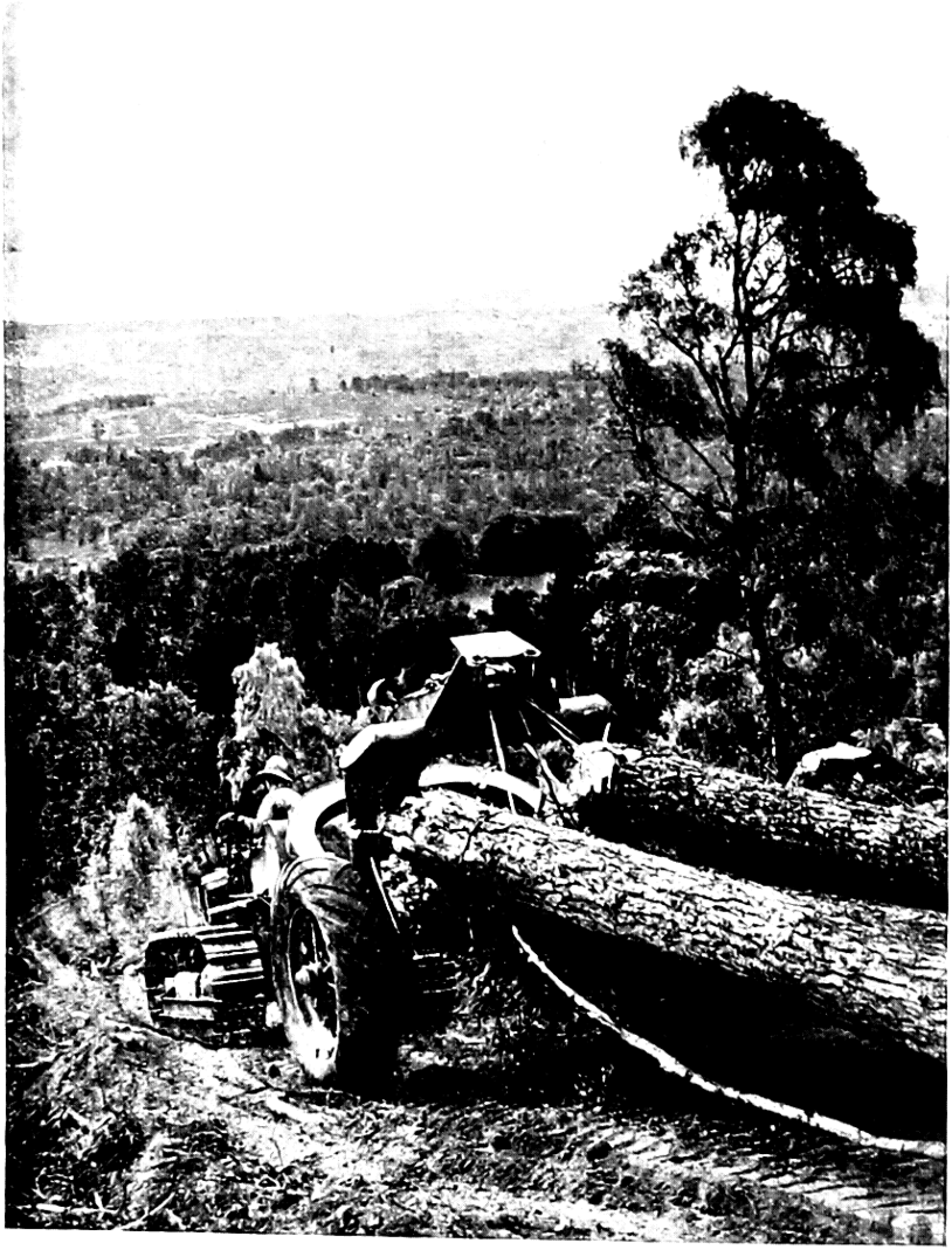
TIMBER CARRIAGES. After tushing to a hard road, the logs are next loaded on to timber carriages. The typical timber carriage or pole waggon consists of two pairs of wheels united by a single pole; the forward pair of wheels is free to swivel, for steering purposes. As the weight of the timber rests on the cross-frames above the wheels at each end, there is no need for a square body such as is found on other vehicles; indeed it would only add unnecessary weight. Pole wagons are drawn by horses, tractors, or motor lorries equipped for towing work (149). The length of their body can be adjusted by varying the position of the rear pair of wheels along the pole, to suit loads of varying lengths. For road work efficient brakes are essential, as the load is both bulky and heavy. Timber haulage is highly skilled work; a horse-team must be well trained to pull together, whilst a motor lorry or tractor has to face very rough going with consequent heavy maintenance. Where timber lies remotely from a hard road, it may yet be loaded on to a pole-wagon close to its point of felling, for a tracked tractor can draw a rubber-tyred wagon out over soft or rough ground; then, without the expense of unloading, the wagon can be handed over to a motor towing unit as soon as the hard road is reached, and so be sent over main roads for any distance; in the meantime the tractor can return to the woods with another, unloaded, wagon which it has taken over from the road vehicle.

LOADING TIMBER. Timber is tushed to the road, and is hauled along the road, in its *lengthwise* direction, but loading is usually done *sideways* by the process called *parbuckling*. The log is drawn to the roadside and pulled so that it lies parallel with the timber carriage, and a few feet away from it. Small ramps are then laid down at each end of the carriage, to form inclined planes rising from ground level to the carriage bed, some three or four feet from the ground. Two wire or fibre ropes are then fixed, one at each end of the carriage. These pass beneath the log, and are then carried over it and on over the top of the carriage, where they are brought together and united.

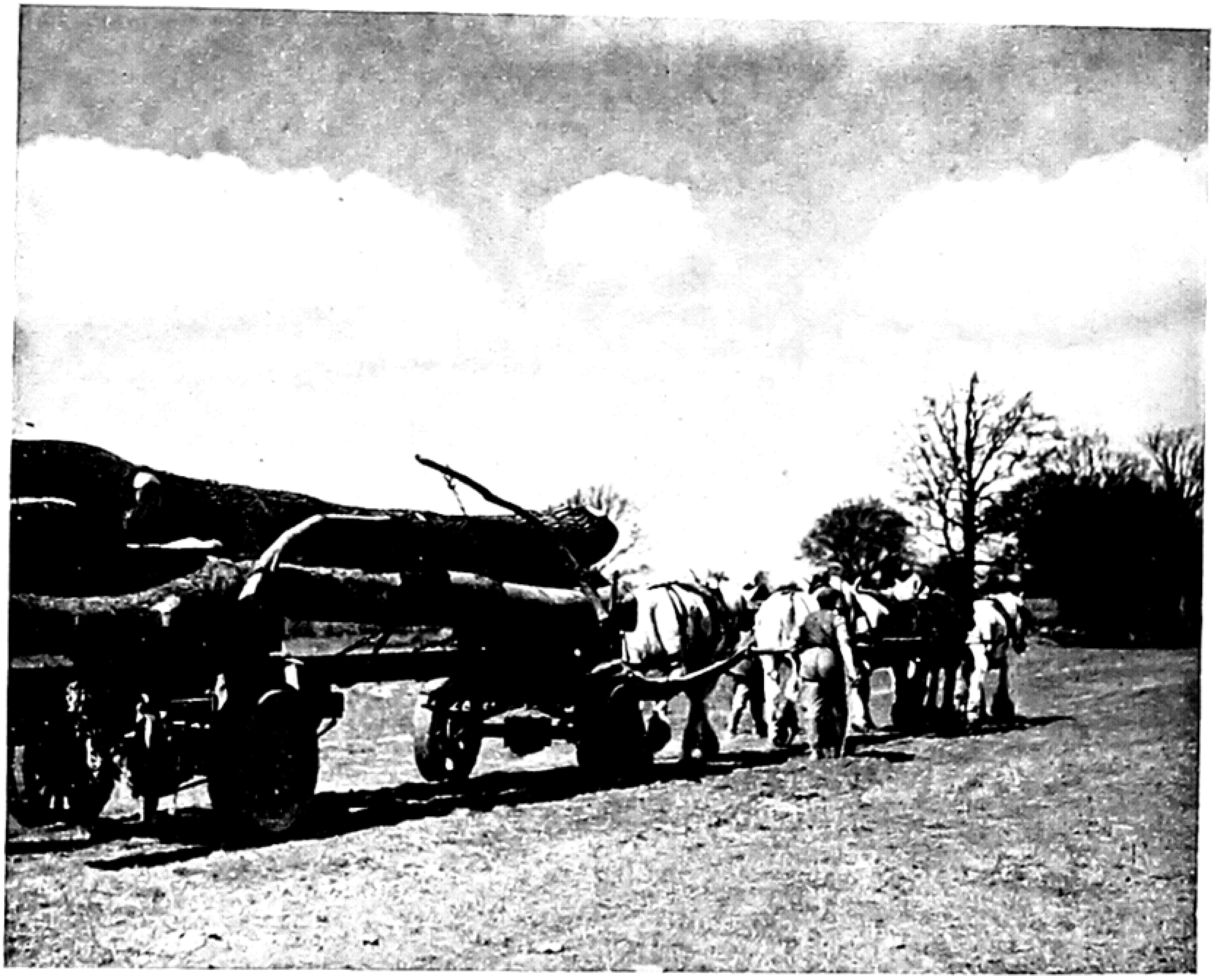
The horse or tractor which has drawn out the log then proceeds to this opposite side, and the united rope is coupled to it, When all is ready, the horse or tractor hauls away, moving off from the carriage in the direction away from that in which the log lies. As the ropes take the strain, the log is drawn towards the ramps, and rolled up them on to the carriage bed. Once there, it is secured in place by steel spikes and chains at each end.

This method enables logs weighing several tons to be loaded without special equipment. It utilises two fundamental mechanical principles, those of the inclined plane and the pulley. The alternatives of using cranes or sheer-legs are now rarely seen, for tractors are able to parbuckle the largest logs grown in British woodlands (150).

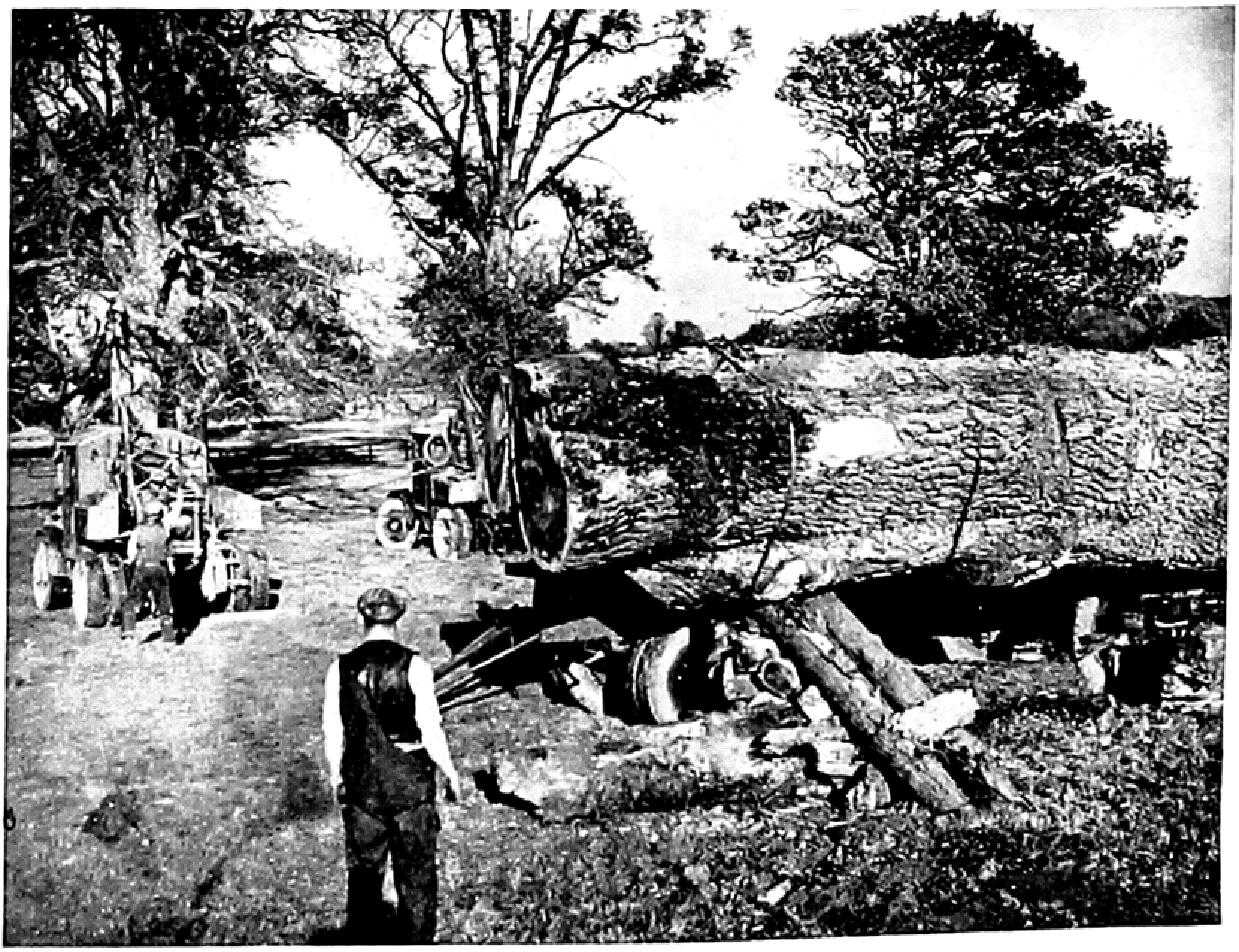
FOREST ROADS. The process of tushing is a costly one, for only one or two



148 A CRAWLER TRACTOR AND SULKY OF THE CANADIAN FORESTRY CORPS, HAULING LOGS FROM THE WOODED SLOPES ABOVE LOCH NESS



149 A HORSE-DRAWN POLE WAGON



150 TRACTORS, EQUIPPED WITH WINCHES, PARBUCKLING HUGE ELMS AT LLANARTH, MONMOUTH

logs can be handled at a time, and wear and tear on equipment is heavy. By comparison, road haulage is cheap, for several logs go to a load, and friction, wear and tear, time taken, fuel consumption, and labour costs are less per mile when the load travels speedily on a wheeled vehicle. The nearer, therefore, that a hard road approaches to the growing trees, the less will be the cost of their extraction. Furthermore, the lower the costs of extracting timber from the woods, the more the owner can demand for it. So it is often a sound policy to construct a system of good roads into the heart of the woodlands, for their cost can be recovered in the higher prices obtained for the timber, and they also aid fire protection and general administration. Consequently the forester on occasion turns engineer, and plans or constructs roads on an extensive scale.

Tarred or concreted roads are too expensive for forest use. Instead, stone or gravel roads are built on the principles laid down by Macadam, adapted to suit local needs and materials.

The line of the road is first decided upon. Usually it will follow an existing track, but it may be necessary to make deviations to avoid obstacles such as streams or steep hills. Ideally, a forest road should follow an even gradient, leading downhill out of the forest. It must avoid sharp corners, for a long timber carriage simply cannot turn them. Patches of soft ground, steep slopes and cuttings have to be avoided as far as possible, and bridging kept down to the minimum essential, as it is costly. Timber loads weigh heavy, and rest upon two axles only; a firm foundation is therefore required.

The bed of the road has to be at least twelve feet wide, and slightly cambered, with a shallow drain on either side to carry away surface water. On this is laid a layer of large stones or coarse gravel. This is capped with a layer of finer gravel or smaller stones, which work into the interstices of the coarser material below, gradually binding the whole into a firm surface. The thoroughness with which the road is metalled will depend on the intensity of the traffic, and the hardness of the existing bed which lies beneath it. A width of at least eight feet of metal is required; sometimes the metalling of the wheel tracks alone will suffice. Normally, traffic and weather consolidate the surface, and it is not necessary to employ a roller. Drainage is all-important, and it may be necessary to insert culverts at frequent intervals to carry water from one side of the road to the other, more particularly on hill-sides.

Forest roads are permanent structures, and therefore require bridges of lasting materials, such as stone, brick, or concrete. But timber serves well at a pinch. It is readily available in the forest, and though timber bridges have a limited life, they are readily replaced. For small gaps, oak baulks or creosoted railway sleepers, supported by concrete abutments, meet the case very well. Concrete culverts are another cheap form of construction for small crossings.

In marshy ground, and tracts of soft sand or clay, roads require a foundation of brushwood. This is laid *crosswise* along the road-bed, and should be covered over with finer fibrous material, heather being ideal for the purpose. Coarse gravel is laid on the heather, and finer gravel for the surface. The traffic, pressing down, binds the gravel, which cannot force the heather down through the brushwood, or itself penetrate through the mat of heather; the brushwood, in its turn, cannot be driven down through the soft substratum, since its interlacing branches form a substantial mat. Curiously enough, the heather and brushwood do not readily decay, and such roads last indefinitely.

In chalk areas, little drainage is required, and local flints are commonly used as a road metal in place of gravel.

ROPEWAYS. Ropeways are much cheaper to construct than roads, and where a large volume of timber is to be extracted downhill from a forest, can also be operated cheaply, since no power is required; gravity does all the work. They can be constructed where no road could run, down steep hillsides, across streams and valleys, and will probably be increasingly used in the future. In America, complex ropeway systems have been devised to " skid " or draw timber to railways, but these are unlikely to prove of utility under British conditions.

The usual type of simple gravity ropeway consists of a fixed overhead cable made up of many strands of steel wire, securely anchored at the top and bottom ends, which may be as much as a quarter of a mile apart; no intermediate supports are needed. Pulleys travel along this fixed cable, carrying either logs, or loads of smaller poles, downhill. On steep slopes enormous speeds are reached, so that a " buffer " of branchwood must be fixed at the lower end to absorb the shock of the poles striking the ground. The travelling pulleys are returned to their starting point in a bucket, travelling on a pulley, which is let down from the top of the ropeway attached to a fine "running" wire. When this wire is wound up again it draws the bucket and its load back to their starting point.

Such ropeways must follow a fairly uniform slope, which may be concave, as in a valley, but never convex. They must run in a straight line from start to finish. Where the slope is variable or the route is curved, rope tramways may be more effective. In these, two trucks run on parallel sets of rails, and the fully loaded one travelling downhill pulls a cable that draws the empty one upwards.

In yet another form of rope haulage a rope runs *uphill* from the felling point to a road or ride at a higher level. There it passes through a snatch-block, or simple pulley designed to change the direction of a pull, and is attached to a horse or tractor that moves along the road and so draws the logs up to their outlet route. This method enables logs to be extracted from steep-sided glens or valleys, where no road can be built at the lower levels and gravity extraction is impossible.

CHUTES AND SLIDES. Another simple way of getting timber down from the hillsides is to construct a timber slide or chute, which is an open gutter made of steel tubing (half round in cross-section and open at the top), or built up with poles or sawn timber (174). It runs downhill at a steep angle, and though normally straight may follow gentle curves such as those in a valley bottom. When a log is placed in the slide it rushes downhill at an ever-increasing speed until the main problem is to stop it without shattering it. Sometimes the slide ends above a lake, so that the plunge into the water ends the log's wild career, and enables it to be towed to a loading point. In " wet slides " or flumes, a stream of water is diverted from some upland source into the slide, so that it helps to carry the logs downhill.

WATER TRANSPORT. The floating of logs down rivers is seldom a practical proposition in Britain. In the hills, the streams fall too steeply. On the plains, they are navigated by small craft, and logs drifting at random would upset that traffic. On occasion, however, logs are floated across certain of the Scottish lochs and Welsh lakes (172, 173). Timber is well suited to water transport by barge or coastal steamer, but there is little likelihood of loose logs being floated from forest to sawmill on any extensive scale in Britain.

RAIL TRANSPORT. The construction of special railways to serve forests is rarely carried out in Britain; though special sidings are often made to accommodate timber traffic. Abroad, such railways have frequently been laid down, but as a rule to serve large-scale exploitation operations in virgin forests.

The main line railways make special arrangements for transporting timber, and quote rates which are based on the average weight for a given volume of the principal tree species. Unfortunately, their terms have hitherto favoured the importer rather than the home producer.

The question of timber transport is of great importance to the forester, for his crop is both bulky and heavy, and is grown in regions which are often remote from the centres of consumption. Therefore he may find it profitable to study every means of moving it cheaply from the forest to the distant town.

CHAPTER 18

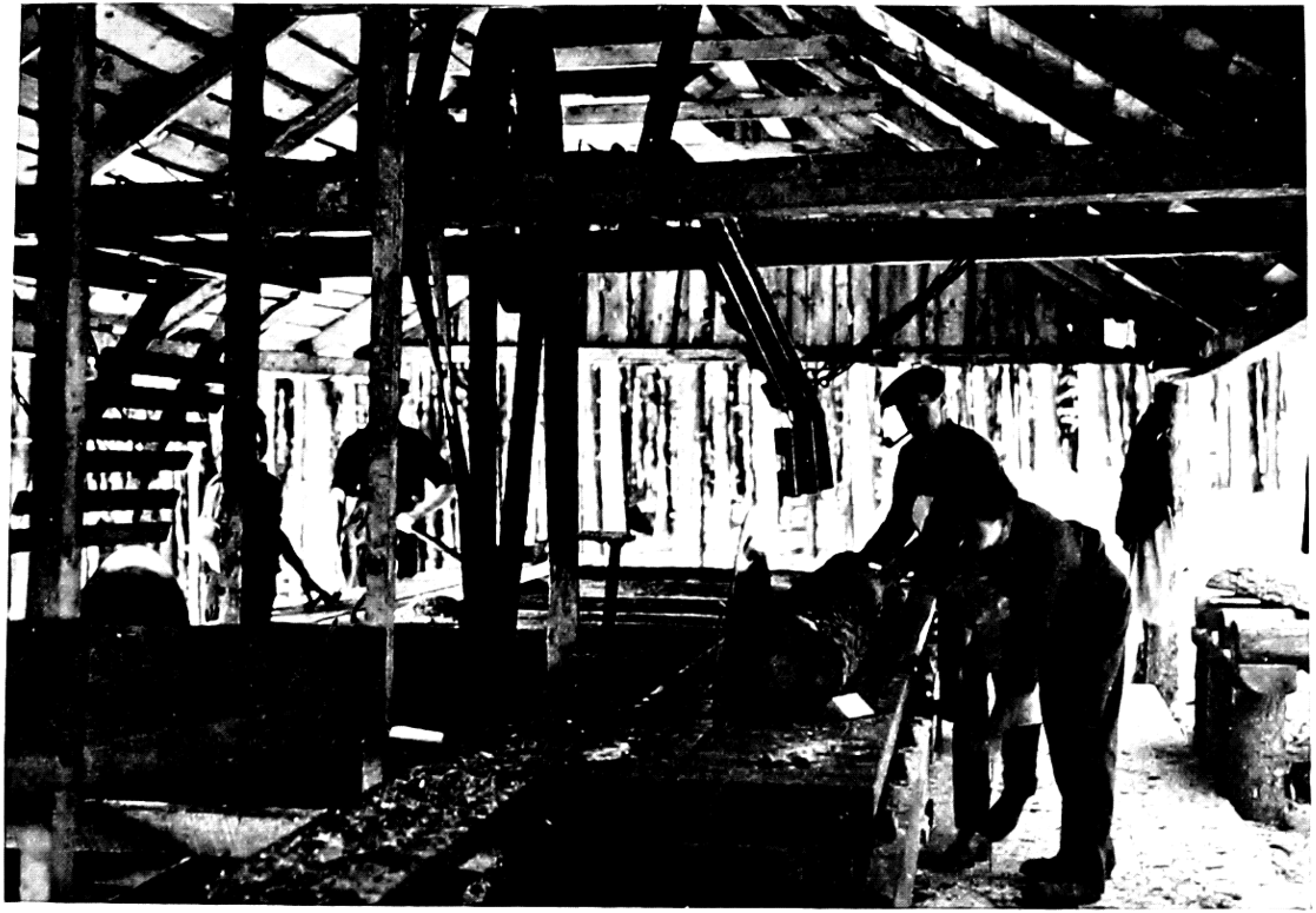
TIMBER FROM THE FOREST

Timber is the main economic product of the forest. As a raw material it is essential to our civilisation, and although for certain purposes it has been replaced by metals, minerals, or synthetic materials, its importance has continued to grow as more and more uses have been discovered for wood and wood products. There can be little doubt that the commerce of later centuries will clamour for timber as does that of the present day.

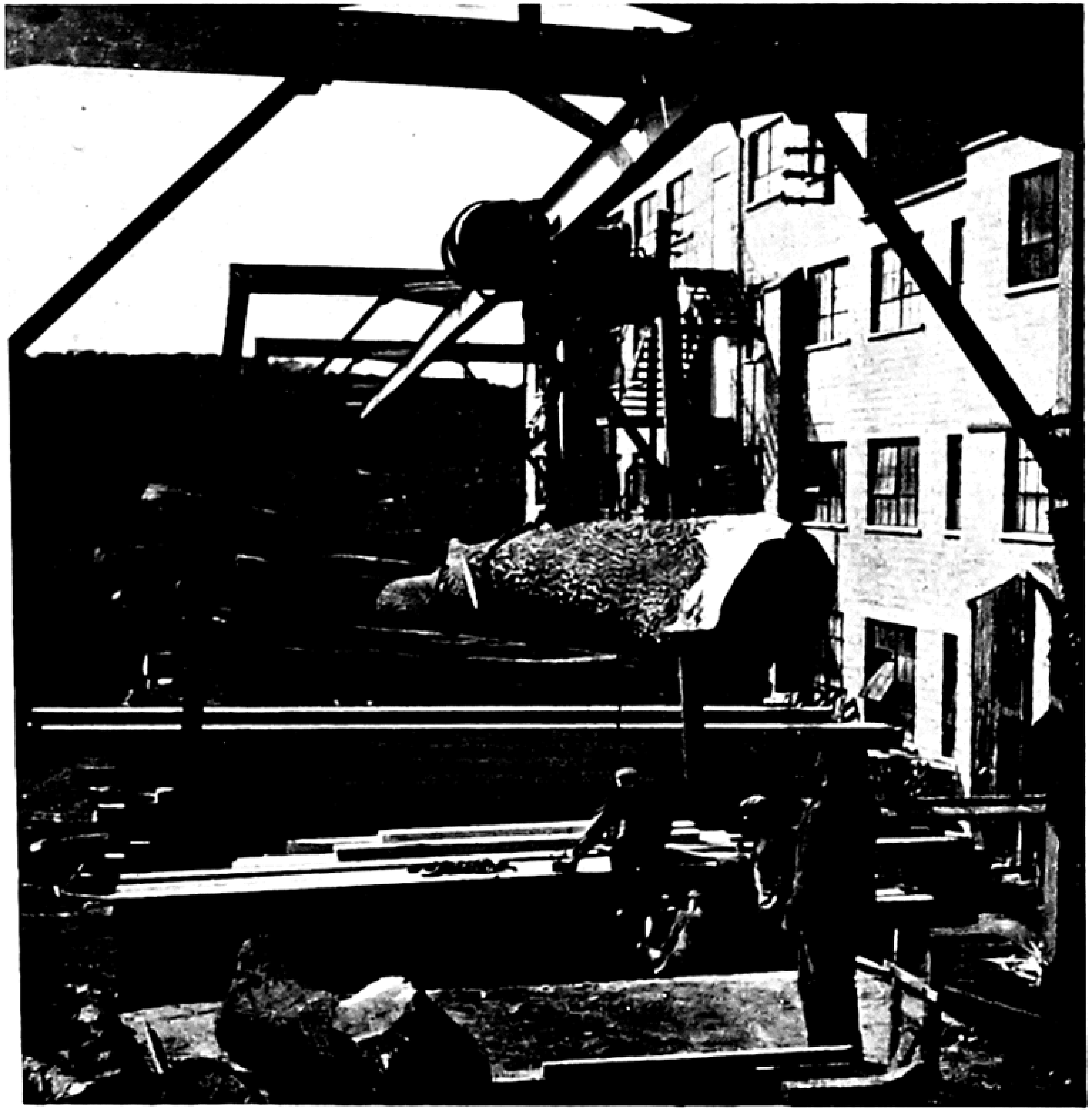
Timber is an intricate substance and its properties have been studied from many angles. Scientists have tested its strength, analysed its chemical composition, and scrutinised its cellular structure through high-powered microscopes. Woodworkers, builders, carpenters, shipwrights and timber merchants approach its study with the technique of their own trades to consider. Here we are concerned with timber from the forester's standpoint, for in order to grow good timber and sell it in the world's markets, the man in the woods must know a great deal about its properties and the various ways in which it is converted to its multitudinous uses.

Timber is the basis of a large proportion of building construction, as joists, beams, rafters, and flooring in houses with walls of brick or stone; whilst it is the staple material for building smaller structures such as sheds and huts, and is used on an extensive scale for building timber houses throughout North America and northern Europe. It is widely employed in mining, engineering, railway construction, and shipbuilding, especially in the construction of the smaller types of craft. As boards or plywood, it forms the principal substance of boxes and packing cases of all kinds. Furniture is mainly constructed of wood. It is the chief raw material for the manufacture of paper and cardboard, and is used also for making synthetic fibres, cellophane, artificial silks, and packing materials. Further it is an important source of plastics, and can be made to yield alcohol for use as fuel, and even animal feeding stuffs. Large quantities are used in making lorries, waggons, and motor vehicles of many kinds, as well as railway rolling stock and some types of aeroplanes. Important subsidiary uses include handles of many kinds, parts of shoes, bobbins, barrels, baskets, tableware, and toys. The list is wellnigh endless. From the cradle to the coffin we live in a world of wood.

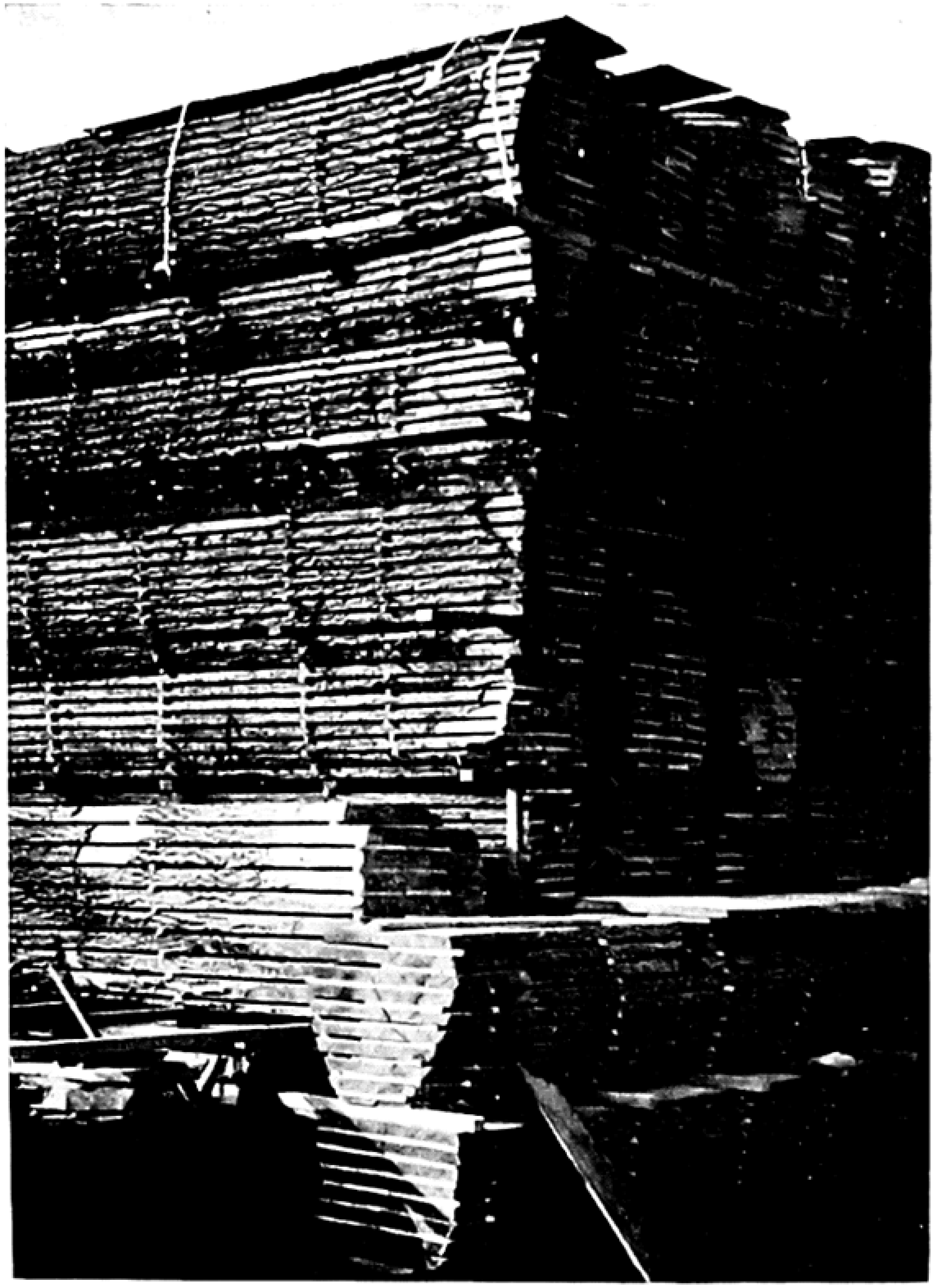
Curiously, every apparent replacement of wood by another raw material is apt to result either in the use of wood in some other form, or to extend the demand for wood as an auxiliary material. When wooden boxes are replaced by cardboard ones, it may merely mean that *pulped* wood is being used instead of sawn wood. Plastic panelling substituted for woodwork often consists mainly of ground wood or paper, both made from timber. A modern steel liner uses more timber than an old wooden battleship in its building. Even the mineral coal which has replaced wood as our principal fuel, is only a prehistoric forest in fossilised form.



151 SQUARING A SCOTS PINE LOG AT A SCOTTISH SAWMILL, SHOWING HOW THE CIRCULAR SAW WORKS IN A GROVE OF THE MOVING RACK BENCH



152 BRINGING A HUGE HOME-GROWN ASH LOG TO THE SAWBENCH OF A HIGH WYCOMBE FURNITURE FACTORY



153 HOME-GROWN ASH PLANK STACKED TO SEASON

THE QUALITIES OF TIMBER

In every part of the world timber has gained an assured place in commerce and manufacture. In treeless deserts, such as those of the tropics and the far north, it ranks as an essential import as soon as civilization reaches their shores. Its importation is essential to the economy of countries such as Britain, which consume far more timber than they themselves produce. On the other hand, countries with a surplus of timber available for export, such as Sweden, find it an invaluable asset in their international trade.

Timber owes its importance and widespread use to a combination of many desirable qualities; other substances excel it in certain directions, but each has some drawback from which timber is free.

First, it is easily worked by simple metal tools, and is also readily adaptable to mechanised processes. Thus it can be sawn, split, carved, planed, moulded, bent, bored, and in general shaped to any design, much more easily than either stone or metal.

Secondly, it is extremely strong for its weight, selected timber and its derivatives sometimes surpassing aluminium in this respect, and replacing it at times in aircraft construction. Yet despite its strength, wood is generally tough, supple, and rarely brittle.

Thirdly, it is light for its bulk, which property enables it to be handled readily, and is an asset in building construction, and in shipbuilding. Most timbers float, and their low density aids transport by water, either as loose logs or in rafts of timber.

Fourthly, wood is a poor conductor of heat, and also of sound, both valuable qualities in a building material. It is likewise resistant to the passage of liquids, so that it can be used in waterproof construction of many kinds, such as boatbuilding, making barrels, and roofing buildings.

Fifthly, it is moderately durable, and moreover is receptive to preservative substances, such as creosote, which prolong its useful life indefinitely under conditions which otherwise favour decay.

Sixthly, it is attractive in appearance, especially if cut to reveal the beauty of its " figure "; and its surface is readily treated with paints, stains, varnishes, and polishes, so that it lends itself to decorative treatments of many kinds.

Other points of value are its comparative cheapness, its easy transportability, availability in large quantities, standard grades and adequate dimensions, and the fact that its uses and properties are widely known and well understood by the craftsmen of many countries. It is neither harsh nor cold to the touch and so has a marked advantage over metal for use as domestic furniture. It wears well. Wooden articles are friendly things about our homes. A pipe or a walking stick becomes a treasured possession through long association, and an old oaken bucket may give good service for so long that at the end its memory is preserved in song.

No other common raw material has so many virtues, so few vices. Its fibrous structure enables it to hold nails and screws. It bends before it breaks, and if subjected to crushing strains, gives warning by creaking or groaning before its final collapse. It is resistant to acids and alkalies. Though it burns, it may be treated with chemicals so that it can resist fire; and it is even used to protect metal from heat in fireproof doors and bulkheads. It is readily adaptable to uses in which its firm yet supple strength is supplemented by the different strength properties of other materials. For example, in bridge-building, wooden uprights or beams may be bored through without undue loss of supporting power, so that metal bolts may be inserted to bind the whole structure firmly together, whilst the use of modern metal " timber connectors " makes a still stronger structure. In the rigging of sailing ships, wooden masts and spars are enabled to take their stresses and strains by the ropes which stay them. Wood may be joined to wood in a number of ingenious ways, by interlocking mortises and tenons, dovetailing, by screws, nails, or glue, and even by *sewing* one plank to its neighbour, as is done in the making of coasting boats in southern India.

Timber, too, is highly divisible. It may be split into thin sheets or pieces without losing its main properties; and these sheets or pieces may be rebuilt, as in plywood and laminated wood, to produce new materials stronger than the original wood, and also more uniform. The further breaking down of wood into its constituent fibres enables it to be reconstituted as paper, cardboard, or papier mâché. If dissolved with chemicals, it can re-arise as cellulose, cellophane, or artificial silk, whilst valuable resins, tars, and wood oils can be extracted from certain timbers by chemical means. There are uses, too, for the by-products which arise from the processing of timber; sawdust can be used as a fuel, and is a serviceable packing material for some kinds of goods, as are the shavings which are thrown aside when wood is planed. Wartime shortages have shown us that wood can be salvaged, as from bomb-damaged buildings, and used again, even if only as a temporary expedient.

It is unlikely that man will ever produce a synthetic substitute possessing all the varied qualities of wood, on any large or economic scale. For timber is a *rigid* substance compounded of a myriad *flexible* fibres. Synthetic fibres, and rigid synthetic substances, can indeed be made; but to combine the two into one substance, with all the properties of wood, would tax the scientists' ingenuity to the utmost. The natural product of the forest has its future assured by its varied and inimitable qualities. These vary in some degree from one kind of timber to another; as a rule, there is a kind of timber best adapted to each purpose, but a use of some kind can be found for them all.

The advent of plastics has increased rather than diminished the total demand for wood. Many of the active constituents or " plasticisers " can be prepared from timber, and in countries where timber is plentiful it is likely to become the main source of these ingredients. But even if the plasticisers come from alternative sources, wood in one form or another is generally used to form the bulk or body of the plastic substance. Examples are ground or powdered paper, derived from wood, and wood flour, which is obtained by milling it. Plastic resins have already revolutionised plywood and laminated wood construction, owing to their ease of application compared with natural glues, and their water-resisting properties.

Technicians are no longer content to use wood as they find it. They modify its qualities by impregnation with chemicals or by physical treatment. One such " improved wood," known as " Hyduligum," made by compressing light laminated birch wood in two planes of direction, is denser than water and so strong that it is used for modern aeroplane propellers in preference to metal.

HOW TIMBER IS FORMED

Timber is formed as a living portion of the tree's structure. It is composed of specialised cells, which make up tissues devoted to three main functions:

1. Transport of sap *up* the tree.
2. Supporting the weight of the crown of foliage, and holding it firmly despite the pull of the wind. This implies that every piece of wood is tested by natural forces as it grows.
3. Storage of nutrients.

Every tree produces these complex tissues, which have been described in detail in Chapter 2. Where trees are grown for the specific purpose of timber production, the forester is able to modify their relative proportions to obtain rapid growth in volume, high quality, or both. He can develop the form of his timber stems so that clean straight logs of adequate length and large diameter are produced in the shortest possible time. Thus he gains much quicker and surer results than are obtained by the haphazard growth of trees under natural conditions, or from trees planted purely for ornament or shelter; such trees yield useful timber, but in quality and rate of production per acre they are easily outstripped by the planned plantation. No two trees build up their timber on precisely the same plan; it varies from one species to another, and also according to such factors as soil quality, exposure to wind, weather, seasons of drought, and accidental damage. All these affect quality, strength, price, rate of growth, and the profitability of the crop.

TIMBER STRUCTURE

The main mass of timber consists of conductive elements, strengthened by fibrous cells, which are laid down concentrically, forming *annual rings*. In spring, these conductive tissues are laid down rapidly by the *cambium ring*, and form an open-textured layer with higher conductive capacity and comparatively little strengthening fibre. In summer, when the need for new channels for the upward movement of root sap is less urgent, a denser layer with smaller or fewer tubular cells and more fibrous material is laid down. These two zones, taken together, make up one annual ring. No new tissues are formed during autumn or winter, when the tree is resting (14–16).

If the tree is growing rapidly in height and in the girth of its trunk, the annual rings are broad, perhaps half-an-inch wide, giving *wide-grained* or *coarse-grained* timber. But if the tree increases in girth more slowly, *close-grained* timber with rings only an eighth of an inch wide or less results. Each type of timber has its merits for certain purposes. Volume for volume, wide-grained timber is produced more quickly and so more cheaply than close or fine-grain material, but the latter is usually of the better quality, and stronger.

Enmeshed with the rings, but lying radially, the *medullary rays* serve for storage, and give to many timbers an attractive *figure*.

The central core of the log is, in mature samples of most species of tree, darker, harder, stronger, and more durable, for its pores are filled in and closed up, and its whole substance is impregnated with preservative substances of natural origin, such as resins or tannins. This is the valuable *heartwood*, lying at the heart of the tree. The outer zone, still open to the passage of sap, is termed *sapwood*.

GRAIN AND FIGURE. "Grain" denotes the general texture of the timber, but the term is used in several senses by timber workers. Thus, *end-grain* is the texture as seen when exposed by a cross-cut; *cross-grained* timber has breaks or twists in the run of its fibres, making it tough and difficult to split; cutting *with the grain* refers to any sawing or cutting lengthwise, parallel to the main axis of the log; cutting *across* or *against* the grain refers to cuts made across the main axis. *Wide*, or *coarse*, and *fine* or *close* grain, have been described above, but there are still two further uses given to this common but confusing term. *Side-grained* or " slash-sawn " timber is obtained by sawing up a log close to, and parallel to, its outer perimeter; such a saw-cut, more or less on a *tangent* to the log's circumference, cuts through few annual rings, and exposes the edges of those that it does cut in irregular outlines. But *edge-grained* or " rift-sawn " timber, obtained by sawing through the log lengthwise close to its radius or diameter, cuts through all or nearly all the annual rings of the trunk, and these appear as a series of parallel lines.

" Figure " denotes any decorative effect seen on the surface of a piece of timber, but it arises in different ways in different kinds. In oak, it appears at its best when the medullary rays are exposed; that is to say, when the log is cut radially and the surface of the plank is edge-grained. In walnut, it arises through the alternation in colour and texture between spring and summer wood, and shows best on a side-grained surface. " Bird's Eye " figure is produced by minute knots; " Burr " figure by deformities in the tree trunk, and " Oyster-shell " figure by oblique cutting; there are many other varieties.

SIZE AND QUALITY

Timber is customarily measured by volume rather than by weight, and valued at so much per cubic foot, or in some similar units which can be converted to that standard. Like any other commodity, its value varies with variety, accessibility, the quantity offered, current demand and supply. But there are other factors affecting its price which are peculiar to itself.

Firstly, large logs of timber command higher prices out of proportion to their size. For they can be used for purposes for which smaller ones are unsuitable, they contain more heartwood, and they can be converted to sawn timber more economically and with less waste. So for sale purposes round timber is divided into *categories* according to its girth (or quarter-girth), and the price *per cubic foot* for logs in the larger girth categories is often two or three times that of those in the smaller-girthed ones. As a rule, therefore, it pays the forester best to grow big timber rather than small.

But price is influenced by quality as well as by size. Big logs, if very coarse-grained and full of knots, may only be suitable for the roughest work, for they cannot stand sawing out to small-dimensioned material. Quality in timber is difficult of definition, for it varies with both the kind of tree and the purposes for which it is to be used. Nevertheless definite grades are recognized, and the main exporting countries operate grading schemes which govern prices.

DEFECTS IN TIMBER

The quality of timber is naturally affected by the presence or absence of defects, but as these are seldom visible until the log is sawn up, it is advisable when selling round timber to have some definite agreement as to who should bear the loss if a portion of the log has to be discarded. A forester who understands the main defects can guard himself against any attempt to bring down the price of a parcel of timber on the grounds that they are unduly numerous, especially if he is able to visit the merchant's mill and see for himself how much of each log has actually to be rejected as useless.

SHAKE. Shakes are cracks running lengthwise in the tree trunk, and are caused by some strain in growth or felling. "Cup" or "Ring" shakes follow the annual rings; "Star" shakes follow the medullary rays. Shakes seldom extend far up the trunk from the butt, but if they are widespread the log may literally fall to pieces when it is sawn up.

UPSETS. These are cracks across the trunk, due to some sudden shock such as the impact with the ground when the tree falls.

ROT. The heart of a growing tree may be attacked and decayed by fungi such as those of the *Fomes* group, described in Chapter 8. In the case of conifers, the rot frequently arises at ground level, as infection occurs through the roots, and spreads up the tree. Hence it is known as "Butt rot," and it may cause the otherwise valuable butt length to be thrown aside as worthless. In the case of broadleaved trees, rot frequently gains entry through some broken or dying branch, and so damages the timber at a higher level. Rot is commonest in over-mature timber. It may limit the age to which a tree crop of a certain kind may be profitably grown on certain sites (79).

EMBEDDED IRON. Iron nails, pieces of fencing, and parts of tools occasionally become embedded in tree trunks, and completely concealed from view. In sawing up, the whirling saw bites into them, and its teeth may be stripped. For this reason, growing trees should never be used as supports for metal fencing or notice boards. A merchant who buys "hedgerow timber" takes the risk of this defect, and so can only afford to pay a low price for the material.

KNOTS. Knots occur in all tree trunks, and they are seldom ranked as a serious defect unless they are unduly large or numerous. "Live knots" are the remains of branches which were embedded in the log by the natural expansion of the tree trunk whilst they were still alive; they are united with the other tissues around them and so cause little trouble. "Dead knots" are branches which had died before the trunk expanded around them. They have no firm connection with the tissues around them, and so fall away from thin boards, leaving round holes. They also form hard obstructions to the working of the timber. Dead knots can be largely avoided by brashing or pruning, and by growing trees in close stands so that no large side branches are formed.

SEASONING

After timber is felled, it loses a large amount of moisture, and so becomes lighter in weight. This process is accompanied by shrinkage. There is little shrinkage lengthwise, and only a moderate amount along the *radius* of the log, but considerable shrinkage occurs *tangentially*, at right angles to the radius. When timber is left to season in the log, this tangential shrinkage results in radiating cracks similar to star shakes. It is therefore the practice to convert round logs to large-dimensioned material, such as planks, whilst their wood is still comparatively "green" or unseasoned. At this stage it is seasoned by one of two methods before being converted further into smaller sized boards or scantlings.

NATURALLY SEASONED timber is stacked in the open air in open piles, usually with sticks between each plank to give air-space and ensure adequate ventilation. Several months or even years must elapse before all the moisture evaporates and shrinkage ceases (153).

ARTIFICIALLY SEASONED timber is treated in a "kiln," a chamber of brick and metal in which temperature and humidity are carefully controlled so that the surplus moisture is removed from the timber in a matter of days, by heating and ventilating.

The purpose of seasoning, in both cases, is to secure a stable material, not liable to further changes in shape or weight. Since the shrinkage which accompanies seasoning takes place in different degrees in different directions, it alters the shape of each piece of timber. Therefore timber cannot be safely cut to small dimensions, nor planed or moulded, until it has been seasoned. Once seasoning is complete, the wood may be worked to accurate sizes without fear of warping, shrinking, or other distortion. Seasoned timber is much stronger, for most strains and stresses, than unseasoned material.

THE CONVERSION OF TIMBER

The process of breaking down timber from the log into other forms is termed *conversion*. This is usually done with saw-milling machinery, at one stage or another of the process, but there are six fundamental methods of conversion. These are :

1. Hewing, with axe or adze.
2. Cleaving, with axe, wedge, or froe.
3. Sawing, with saws of many types.
4. Slicing, by forcing against a knife-blade.
5. Peeling, by rotating against a knife-blade.
6. Turning, by rotating against a chisel.

HEWING

This, the oldest method of conversion, is now only used for special work in Britain, as for example when curved oaken members are required for ship or barge building. In primitive countries its use is still common. It consists in reducing the round log to a rough square or rectangular baulk, or other desired shape, by using a specially sharpened axe, flat on one side and bevelled on the other. An adze may be used to trim up the surface (176). Hewn timber is more durable than sawn, as its surface fibres are not cut across. The craft of hewing, which requires strength and skill, survives in some rural districts where hewn oaken gate-posts are preferred to sawn ones.

CLEAVING

This is the splitting of logs lengthwise, along the radius. It is employed for preparing such items as barrel staves, roofing shingles, palings, and fence posts, chiefly of oak or sweet chestnut, as those woods cleave readily. Cleft material is very durable and highly impervious to liquids. Thus, " tight " barrels of oak, wherein each stave contains at least one unbroken medullary ray, can be used for the storage of alcoholic liquors. Sawing has replaced cleaving for many purposes but the cleaving of small material with billhook, axe, and wedge remains an important woodland craft in Britain (107).

SAWING

The saw is the master tool by which the great bulk of timber is converted. Although it is highly variable in design, the principle of all saws is the same. Every saw is a row of tiny chisel blades set to run in line one behind another. This fact is readily grasped if one examines a circular saw blade with ***detachable*** teeth, each of which is, in fact, a small chisel. Saw teeth are sharpened on the side or on the cutting face, depending on the type of saw. They are also given a degree of " set," that is to say they are made to project on either side of the plane of the blade. " Spring set " saws have alternating points bent towards opposite sides, by means of a special tool called a " saw set." In " swage set " saws a similar effect is obtained by using broad-faced teeth which project on both sides.

The set of the saw contributes to the wastage that inevitably accompanies sawing. Saws do not split the fibres of the timber asunder, as do the tools used in other methods of conversion. Instead they tear through them, and all sawdust is wasted timber. To take a simple case, no sawyer, however skilful, could cut 12 boards, each one inch thick, from a piece of timber one foot thick. The best he could do would be to cut 11. For at least one-twelfth part of the timber would disappear as sawdust, and this inevitable loss must be weighed against the sawmiller's profits.

Obviously the sawmiller endeavours to cut this wastage down as far as possible, and so we find that saws of different types are employed as conversion progresses from the log to finer-dimensioned material. The care of saw blades is likewise important, and a craftsman called a " saw doctor " is employed at large sawmills for sharpening, setting, and trueing them.

CROSS-CUT SAWS. These are used to cut across the log, and so differ in design from the types employed for converting timber lengthwise. Hand cross-cut saws vary from light, bow or frame saws, with a thin detachable blade in a bent wood or metal frame, to big " fish-backed " two-man saws, six feet or more in length, used for cross-cutting large timber into lengths suitable for the mill. Machine-driven cross-cuts include a portable circular saw on to which small poles etc. can be lifted, and a portable chain saw which can be handled by two men. But for use in the forest machine saws have few or no advantages, in actual practice, over man's muscles (147).

Within the sawmill, timber is frequently cross-cut at various stages of conversion by power-driven saws, A common type is free to move, under control, like a pendulum, being lowered when required to slice through each piece of timber. Cross-cutting is a necessary preliminary to most other forms of conversion. If a log is to be hewn, sawn, cleft, sliced, peeled, or turned, it is first cut to the desired length with the cross-cut saw.

SAWING LENGTHWISE. This is the major operation of conversion by sawing. Most people are familiar with the carpenter's rip saw. The principle on which this works is used, on a much larger scale, in cutting planks, boards, battens, and most other familiar timber forms from the round log in which they originally grew.

To show the main elements of the process, the progress of a log through a simple saw mill may be followed step by step.

A common type of mill used in the British woodlands, more particularly in Scotland, is described as " portable " because it can be dismantled and moved by road from one forest to another. This takes a few weeks to effect, but is advantageous because it brings the mill close to its source of raw material and lessens the cost of transporting the round logs from the wood. The engine of such a mill is usually a steam one, burning waste wood as a cheap fuel. It provides a steady and flexible source of power, and is mounted on wheels so that it can readily be moved by road. Oil engines are sometimes used, and in case of need an ordinary farm tractor, with a belt drive, will drive a circular saw with reasonable efficiency (151, 161).

The engine drives a circular saw some six feet in diameter, which can cut any log up to three feet thick. The actual saw blade can be detached from its spindle for sharpening and replacement, and may be equipped with detachable teeth. It is set to turn in a gap in a long platform termed a " rack bench." The length of this bench, usually some twenty feet, determines the length of the log that can be cut up ; larger trees have to be cross-cut to this maximum length. The bench may be moved by hand or engine power.

The sawyer and his mate move the log, which has been previously cross-cut if longer than the bench, on to the platform by means of crow-bars, cant-hooks or winches. They set it parallel with the bench, and fix it with the aid of spikes and chocks so that it lies with the line of the proposed saw-cut over the gap in the rack bench.

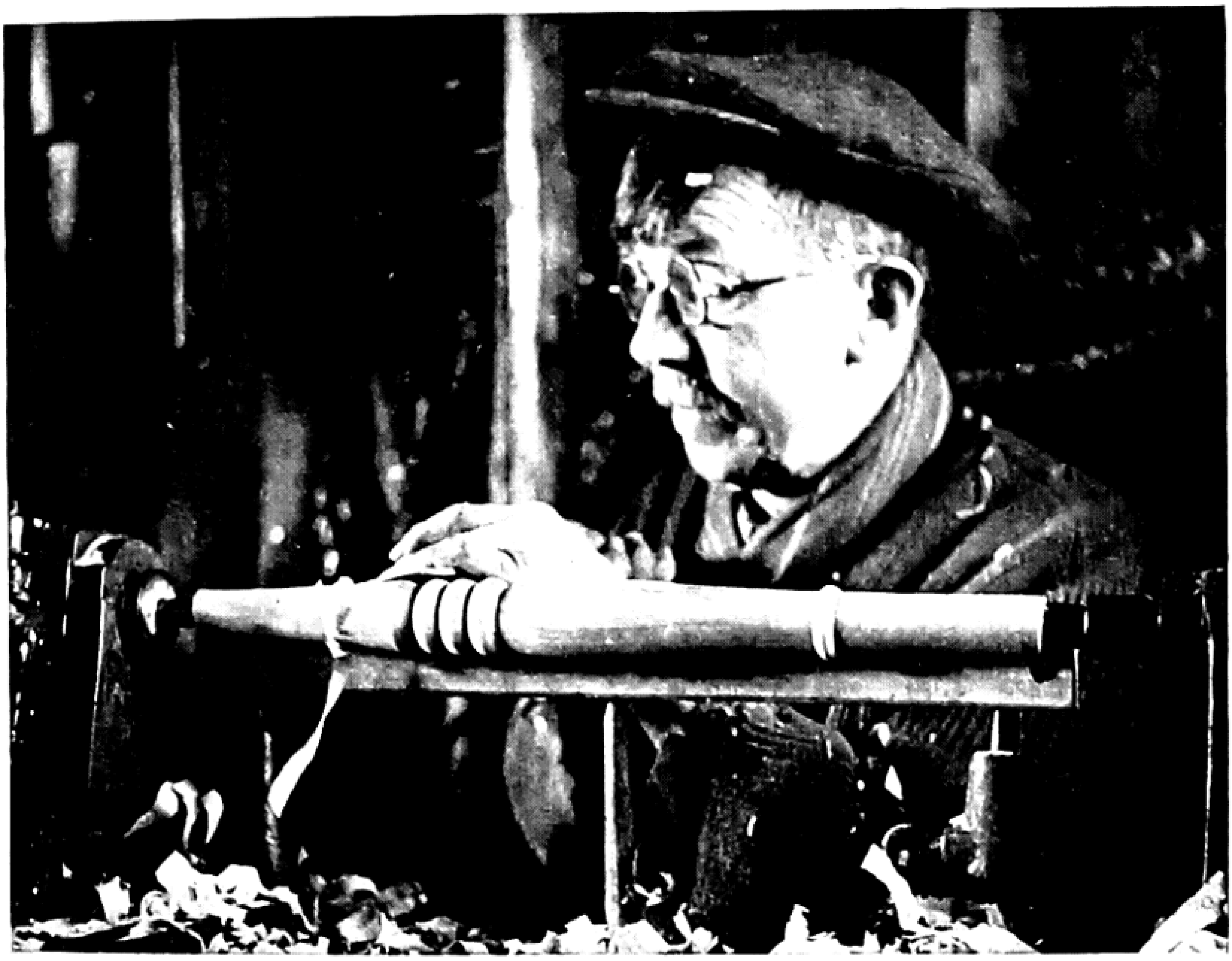
When all is ready, they turn the handle geared to the platform by a rack mechanism, and the whole bench moves slowly forward over rollers, so that the log is carried to the whirling saw blade. With a singing, rending sound the whizzing teeth bite into the wood, making a cut which speedily extends throughout the length of the log as the bench moves on. When the full length of the log has passed the saw, and the cut is complete, a curved section of the log, with its coating of bark, falls away from the main mass and is flung aside. This is a " slab " or " off-cut," and may be useful as firewood or for making rough temporary buildings.

With this first cut completed, the log is wound back to its starting point by turning the handle of the rack. Then the sawyer turns it over on to its new straight flat surface, to give it greater steadiness, and adjusts it for the second cut, which removes another slab. A third and then a fourth cut complete the process of " squaring." Once squared, the log becomes a baulk of sawn timber which may easily be cut up into any smaller sizes that may be required, such as thinner planks, boards, and quartering.

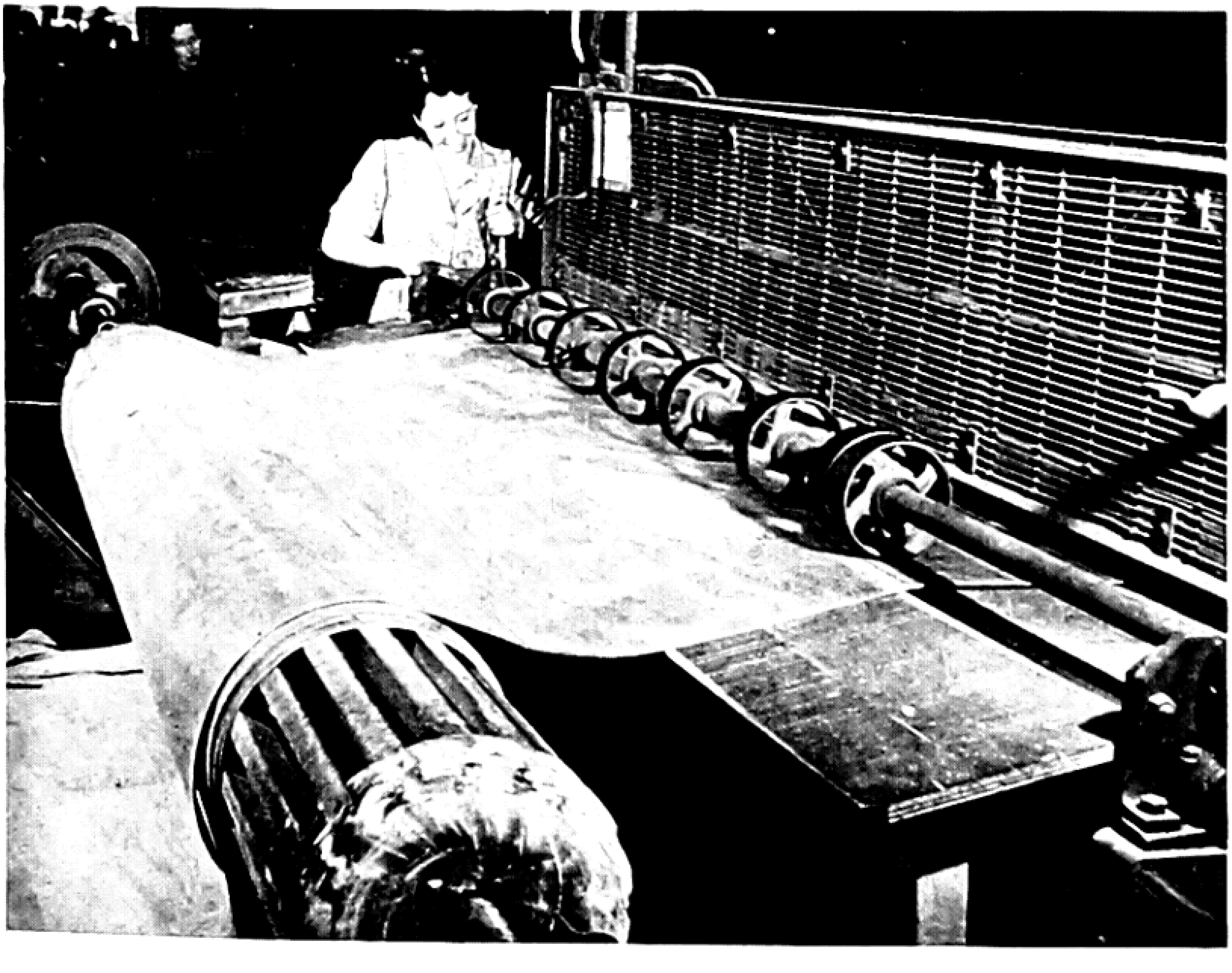
PIT-SAWING. The use of the circular saw is now so familiar that few people pause to wonder how boards were cut from the round log before the machine age. The older method of pit-sawing is happily almost extinct in Britain, though it is still a common practice in eastern lands. Here and there on our large-scale maps the sites of old saw-pits are still shown, mute witnesses of an ancient craft which has died without regrets.

Briefly, the process was to dig a pit, often brick-lined, and set the log over it. Two sawyers then got busy with a huge two-handled rip saw. The leading man stood on top of the log, which was roughly squared with the axe before the work began. He guided the saw by means of a line marked from end to end with chalk. His mate, less skilled or less strong, stood in the pit beneath the log, and took the lower end of the saw. He had no guiding to do, and his pulling, being on the down stroke, was easier, but sawdust fell continually over him. Wages in those days were low, and timber comparatively valuable, but it is hard to conceive of more drudging work.

OTHER TYPES OF MACHINE SAWS. Circular saws cannot tackle very big logs without undue waste, as blades over six feet in diameter encounter mechanical problems in construction and use, and have to be made unduly thick. *Band saws* are therefore preferred for the larger logs, and for accurate work generally. A band saw consists of an endless steel band, bearing saw teeth on



154 TURNING A BEECHWOOD CHAIR-LEG ON A HAND LATHE



155 INSPECTING PLYWOOD VENEERS PEELED FROM A BIRCH LOG

TWO WAYS OF CONVERTING TIMBER

156 TURNING A BREAD PLATTER FROM HOME-GROWN SYCAMORE

157 PIT PROPS AT THE COAL FACE

CONTRASTS IN WOOD USES

one edge, which is revolved around two large wheels, rather like the belt drive commonly used for many forms of power transmission. The log is moved towards the saw on a bench in the same manner as for a circular saw. Band saws may be set to cut either horizontally or vertically. Automatic machinery has been devised for re-sharpening the very numerous teeth which are distributed along their lengthy blades.

RECIPROCATING SAWS, power-driven to and fro like a carpenter's rip saw, are also used. In the type known as the *gang saw*, a reciprocating frame carries several blades which cut up a log into several planks at one time. But most timber is now converted on circular or band saw mills.

It is not possible here to follow timber beyond the sawmill stage, on its progress through many varied industries. Suffice it to say that machines have been devised to carry out all the work of the carpenter and joiner, in its more laborious phases. Planing, moulding, drilling, mortising, boring, carving, and screw-driving can all be done by power-driven machinery. This ready adaptability of timber to modern industrial processing and mass production methods is a great asset commercially, enabling it to compete effectively with substitute materials.

THE CRAFT OF THE SAWYER. The art of sawing up logs to the best advantage demands a long apprenticeship. Not only must the work be done accurately, expeditiously, and without undue waste, but the full potential value of each log must be realized. In different hands, the same length of rough oak timber might be made to yield sleepers for the mines, worth a few shillings only, or good joinery wood, or even valuable veneers, worth a matter of pounds.

Fundamentally there are two ways to cut up a log. *Rift* sawing aims at producing the maximum amount of the surface of the boards *on the radius* of the log ; that is, in the plane of the medullary rays. Sawing *on the quarter* is a specialised form of rift sawing designed to bring out the beautiful ray figure of such timbers as oak. Rift-sawn planks show " edge-grain " on their broad surfaces, and when used for flooring they wear well and evenly.

Slash sawing aims at showing the *tangential* surface of the timber, at right angles to the radius. It is used to reveal the figure of walnut and similar timbers. Slash-sawn planks show " side-grain " on their broad surfaces.

Where these details are of minor importance, that is, for the great bulk of general purpose timber, the sawyer carries out *bastard* sawing, or " through-and-through " work. That is to say, he runs the log through the mill without arranging the saw-cuts in any special direction relative to the radius of the log, concentrating instead on obtaining the greatest possible volume of useful timber. This is a compromise method, producing some slash-sawn and some rift-sawn planks. But even in bastard sawing, the very centre of the log should not be shown on the face of any board or piece of quartering, as its soft pith is unsightly and ranks as a defect if exposed to view and wear.

SLICING TIMBER

This process is used to cut out thin boards for some kinds of boxes, laths, and certain veneers and types of barrel staves. Selected billets of sawn timber are forced by powerful machinery against a stationary blade, which slices off a thin layer. In an alternative arrangement, the billet of wood is fixed in a frame and the blade moves against it. For box-boards, the timber is softened by steaming before it is sliced. Oak veneers are sawn or sliced, as they must be cut on the radius of the log, or " true quarter " to show the medullary rays. There is less waste in slicing than in sawing, as the material is split apart and no sawdust is formed.

PEELING VENEERS FROM LOGS

This somewhat resembles slicing, but the log is softened by steam and then *rotated* against a fixed blade, set so that it continuously skims off a thin layer of wood. The powerful machinery is adjusted so that the knife works closer to the centre of the log with each revolution. Thus the log is " unwound " as though it were a roll of carpet, and a long strip of thin veneer is produced. This veneer is then heated and dried (155).

Peeling veneers is the basic process of the plywood industry. Three-ply-wood is made of three peeled veneers glued together. Formerly natural glues were used, but nowadays the usual adhesive is a plastic resin which can be spread in the form of a thin sheet, and then made to unite the layers of wood under heat and pressure. The outer " plies " are frequently of birch, the centre one of spruce, but many other timbers can be used. The plies are set with their grain alternating as between adjacent layers, so that the material works easily in any direction, but is hard to split. Recent developments of veneering and slicing include laminated wood and wood impregnated with chemicals which enable it to resist fire, rot, and damp, whilst enhancing its strength and working qualities. These combinations open up new fields for the use of timber.

Peeling is also used for cutting many kinds of ornamental veneers, and also for obtaining the thin layers of willow or poplar wood from which chip baskets are made. Logs for peeling must be straight, cylindrical, and free from large knots. Knots of all sizes are apt to cause holes in the veneer, but for work which is not of the highest quality these can be repaired by plugging. Peeling logs must also be of large diameter, for the knife blade cannot cut close to the heart of the trunk, and so the central core of the tree trunk has to be discarded and put to some other use.

WOOD TURNING

Timber, like metal, can be worked to shape by spinning it in a lathe against a chisel blade. Both round poles and sawn billets are handled in this way to produce articles of round or half-round cross-section. Examples are tool handles, bobbins, spools, broom-heads, chair legs, bowls, ash-trays, egg-cups, skittles, and children's toys (154, 156).

BENDING

After softening by steam treatment, many timbers may be bent so as to assume a new shape, which they retain after drying out and cooling in a press. This process is much used for making bentwood furniture, particularly in the neighbourhood of High Wycombe in Buckinghamshire. Beech and ash are the timbers most generally employed.

OTHER METHODS OF USING TIMBER

So far, timber has been considered as a material that retains, to some degree its original substance and structure during conversion. But it may also serve as a source of very dissimilar materials obtained by breaking it up into fine particles, or even into its constituent chemicals.

Thus it may be *shredded* into small fragments to produce a packing and insulating substance called " wood wool." It may be macerated still further in the process of *pulping*, and after treatment with chemicals reappear in the form of paper, cardboard, or wallboard. And it may even be *dissolved* by more powerful chemical reagents, so that its constituent cellulose may re-arise as artificial silk. Going still further, the chemist can extract from it foodstuffs for farm stock, sugar, and alcohol for use as fuel, by the process of wood hydrolysis.

The first stages of these processes have only been developed on a modest scale in Britain, for the existing forests are not a very certain or adequate source of supply for their raw material. When our forests expand it will become worth while to instal the complex machinery involved, and new industries may be created to match those of northern Europe and North America.

HARDWOODS AND SOFTWOODS

The timber of coniferous trees is termed *softwood*, and is the type usually selected for building construction, box-making, general carpentry, and pulping. In short, it fulfils most of the requirements for timber in quantity, being easily worked and holding nails well. Consequently, over 90 per cent. of the timber normally used in Britain is softwood, the great bulk of it being imported from northern Europe and America. So great is the demand, particularly in time of war, that the establishment of coniferous plantations is likely to be the major task confronting British forestry ; fortunately the chief softwood timber producing trees thrive very well in the British Isles.

The principal British softwoods are the Scots pine, equivalent to the Red Deal imported from the Baltic ; Norway spruce, equivalent to European White Deal ; and larch, which is more durable and strong than either of the foregoing. New introductions from North America, whose timbers are also imported in quantity from the Pacific seaboard of that continent, are Douglas fir, Lawson cypress, Sitka spruce and Western Red cedar or " thuya."

Hardwoods, being the timbers of the broadleaved trees, are widely variable in texture, density, appearance, and even in hardness. Their uses vary accordingly, but in general they are required in much smaller quantities than the softwoods. They make up only a small fraction of our total timber consumption, but a substantial proportion of this is home-grown. Imports reach us from the continent of Europe, North America, and many tropical lands.

Of the native hardwoods, oak, strong and durable, is adaptable to a wide range of purposes, both constructional and decorative. Ash, valued for its supple strength, is used for tool handles, sports goods, and in vehicle construction (152). Beech, strong and working well in every direction, is a general purpose timber employed on a large scale for furniture making and a great variety of small articles of everyday use. Each of the hardwoods has a particular value for some special purpose, and the more important of these uses are detailed in Chapters 3 and 4. But this does not imply that they cannot be adapted to other usages, and the development of new techniques may lead to the planting of species so far regarded as being of little value. For example, plywood may be made from birch, and match stalks from aspen. On the whole, however, the demand for hardwoods is unlikely to reach or even approach that for softwood timbers.

CHAPTER 19

POLES, BRANCHWOOD, AND MINOR PRODUCE

Sawmill timber is the main product of the forest, and brings in the chief monetary return. But its growth in close plantations involves the production of poles of all sizes, as the produce of the thinnings which are made at various stages, and also branchwood from the top of each timber tree. These by-products are important both in quality and value, and the forester has to know how to cut and sell them to the best advantage ; otherwise the growing of his main timber crop may show a loss rather than a profit.

Coppice material, which arises from the stumps or " stools " of broadleaved trees cut down to the ground level, is used sometimes in the form of poles, sometimes in the same way as branchwood, and sometimes in special woodland crafts such as hurdle-making. Other minor products of the forest are bark for tanning leather, resins, foliage, and leaf mould.

ROUND POLES

Most poles are utilised " in the round." That is to say, apart from being felled and cross-cut to length, they receive little or no further conversion except perhaps barking and treatment with preservatives. These round poles vary in size from tomato stakes a few feet long right up to transmission poles for electric cables, eighty feet or more in length and weighing several tons.

The great bulk of the poles available for marketing are derived from the thinnings needed to grow a crop of saw timber, as described in Chapter 16. In marking thinnings, preference is usually given to trees likely to form a part of the final crop of timber. Exceptionally a good tree, such as one suitable for a telegraph pole, may bring in more money if cut as a pole than if left to grow on to timber size, and the forester may have to decide whether it can be spared without detriment to the crop as a whole.

Poles are usually cut down, cleaned up, and extracted from the woods on a piecework basis. Forest workers vary greatly in their capacity for out-turn, and it is a good plan to reward the more industrious in this way. Also, a knowledge of the cost of preparing the poles per piece enables the forester to fix an economic price, on the basis of so much for the timber, and so much for the costs of preparation, and overhead charges.

TOMATO STAKES. This is a term used for garden stakes suitable for tomatoes and other plants. They are usually 4 feet long, and are tied up and sold by the bundle of about 25 pieces. The earliest conifer thinnings may be used in this way, as well as coppice-grown material, but the trade is seasonal, being limited to spring and early summer.

BEAN RODS. These are long slender poles, 1 or 2 inches thick by 6 to 8 feet long, which are sold by the bundle in early summer, chiefly for the support of climbing runner beans.

RAILS. The next size of slender poles are termed rails, and are used as cross-pieces in light or temporary fences. They vary in thickness from 2 to 4 inches, and are available in lengths of from 6 to 12 feet. Their price is usually calculated on a basis of so many pence per foot run. Larch is the most durable, but other conifers will serve, and will last equally long if creosoted.

RUSTIC POLES. These are used in gardens, often with their bark on, for pergolas and ornamental fences. Durable larch is again the species usually preferred. Lengths vary from 3 to 10 feet, and diameters from 2 to 6 inches. Prices vary with length and diameter, and as *twice* the diameter implies *four times* the timber content, the prices for the stouter poles run fairly high.

FENCE STAKES. This is an important outlet for thinnings. Although local practice varies, they should be pointed at their larger or butt end, as the decay which ultimately ends the stake's useful life occurs there, and the greater thickness takes longer to rot through, and contains more heartwood. The most durable timbers for this purpose are Sweet chestnut, and larch. Other timbers, if treated with creosote, have a satisfactory length of life in contact with the ground, but most are perishable if used untreated. From 5 to 6 feet is a usual length for fence stakes, which are sold at so much apiece. Their production is an invaluable aid to agriculture, which forestry alone can supply.

HOP POLES. The " King " poles for supporting the wires on which hops and similar fruit crops are trained, are usually of durable Sweet chestnut. A usual size is 15 feet long, and about 4 inches thick at the centre. Lighter poles, somewhat shorter, are still used in some hop gardens, one to each vine.

BARGE POLES, MASTS, ETC. For work on small craft, thin conifer poles are in demand, but they must be very straight and have little taper. Suppressed trees, removed as thinnings, frequently meet the specification.

LADDER POLES. Exceptionally straight poles, suitable for sawing lengthwise to form half-round ladder lengths, fetch high prices. Only a few species are suitable, spruce and thuya (on account of its lightness) being favoured.

PITWOOD. The cutting of pit props for the mines is a substantial outlet for thinning material, and in times of scarcity young plantations have had to be clear-felled to provide this essential requirement for coal production. Despite its simple appearance, a pit prop requires skilful preparation and seasoning. The different mining districts having widely varying requirements, some taking pitwood in random lengths, others needing props cut to exact sizes, whilst some prefer it to be barked before use. The lengths of props used differ according to the depths of the underground coal seams, extremes being 2 feet and 9 feet. The top or small-end diameter of a prop is about one-twelfth of its length, i.e. a 3-foot prop would have a 3-inch top diameter. This means that the forester is often able to dispose of thinning material of a wide range of sizes. Sales are made as a rule on a tonnage basis, although the weight of each prop decreases as it travels from the forest to the pithead, owing to the natural seasoning which occurs. Transport costs play a large part in the final cost, so that forests near colliery areas have an advantage over those at a distance (157–159).

Imported pitwood has frequently played a major part in this market, and at times home-grown props have found few ready purchasers. It is clearly a risky policy for a country whose main source of fuel and power is coal, to rely on imported pitwood. In time of war supplies are greatly restricted, and even in times of peace the exporting countries are liable to discover alternative outlets for their poles, and so withhold supplies or raise prices.

A large proportion of pitwood comes from thinnings, but some is obtained from the slender tops of coniferous trees felled for timber. Plantations are sometimes grown solely for pitwood, in which case they are left unthinned until about twenty years old, and then clear-felled. As the return is a rapid one, this can prove profitable, although the price per cubic foot of pitwood is less than that for mature timber. Quick-growing conifers, such as Douglas fir, are suitable species for such plantations.

TELEGRAPH AND TRANSMISSION POLES. Selected straight conifer poles are used in quantities for carrying overhead wires, either for telephone lines or electric power transmission. Such poles must pass a strict inspection, but prices run far higher, in the larger sizes of poles, than the same trees would fetch as timber for sawmill work. They are selected whilst still growing in the forest, felled and cross-cut to the specified length, and then barked with special *barking-irons* (160). After seasoning in the forest, they are despatched to a creosoting plant for preservative treatment. The indentations commonly seen on such poles are made in order to help the creosote to penetrate deeply. Only steel can compete with wood as a support for such wires, and its high cost and weight have so far restricted its employment to the larger pylons.

POLES FOR MASTS, TOWERS, ETC. Although the demand is variable, high prices are sometimes realised for trees of exceptional size and straightness, suitable for ships masts, aerial poles, or uprights for tall towers. Towers up to eighty feet in height may be built with single stems as upright supports.

SCAFFOLD POLES. Despite the use of steel, wooden scaffolding is still employed in the building trade, being adaptable to small-scale work and awkward situations. Coniferous poles are preferred, and these should be straight, barked, and well-seasoned.

POLES FOR ENGINEERING. A demand for poles often occurs in connection with engineering operations, such as bridge-building and road construction, and tackle for lifting weights. Selected well-seasoned poles, usually coniferous, are required.

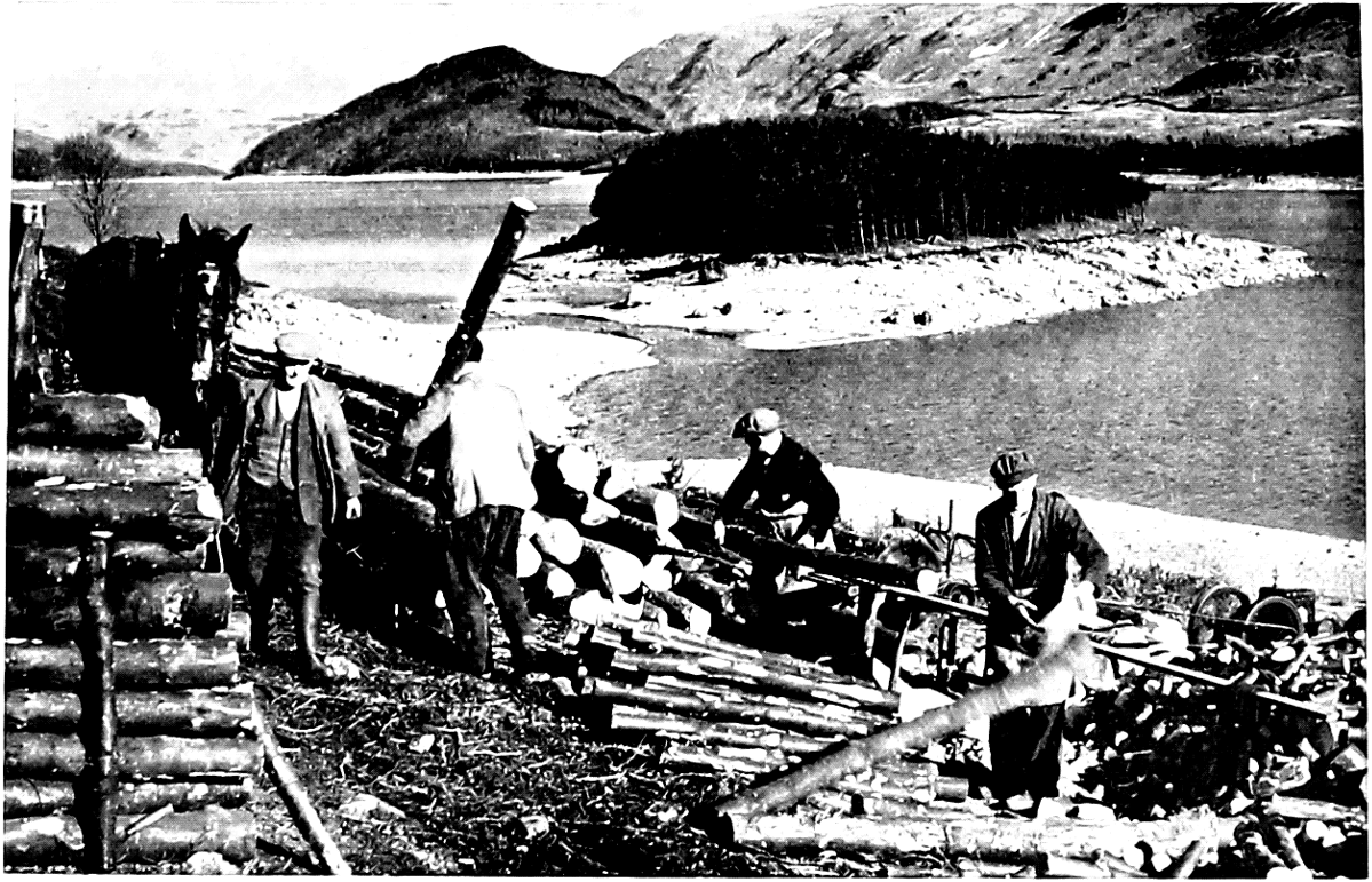
POLES FOR SHIP-BUILDING. Large numbers of poles are used in shipyards, both as scaffolding and as " shores " or ship-props which support the steel hull of a vessel whilst it is awaiting launching.

TURNERY POLES

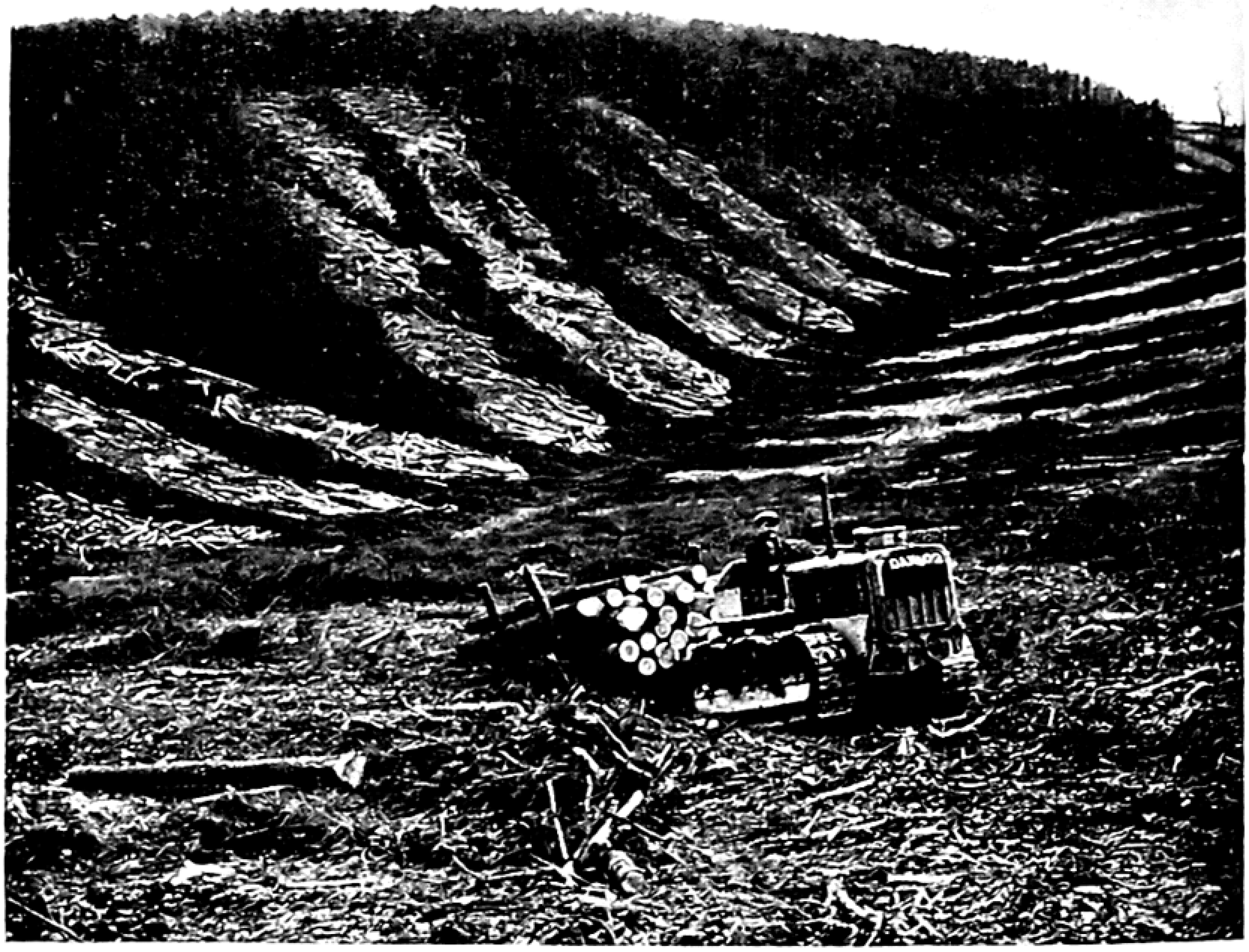
The process of *turning* uses poles in the round, but in a special way. After cutting to length, they are set in a lathe, and spun against a chisel. Portable lathes, driven by a treadle, are used in the Chilterns for the turning of chair legs (154), but most turneries are power-driven factories. Hardwoods such as beech, ash, birch, and alder, are their staple raw materials. Ash is valued for tool handles, and the others yield an enormous variety of round and half-round articles, such as bobbins, bungs, broom-heads, parts of toys, tableware, and items used in furniture making, such as chair legs and backs, rods, and rails. Coniferous woods can also be turned, as may sawn timber of most descriptions.

CLEFT POLES

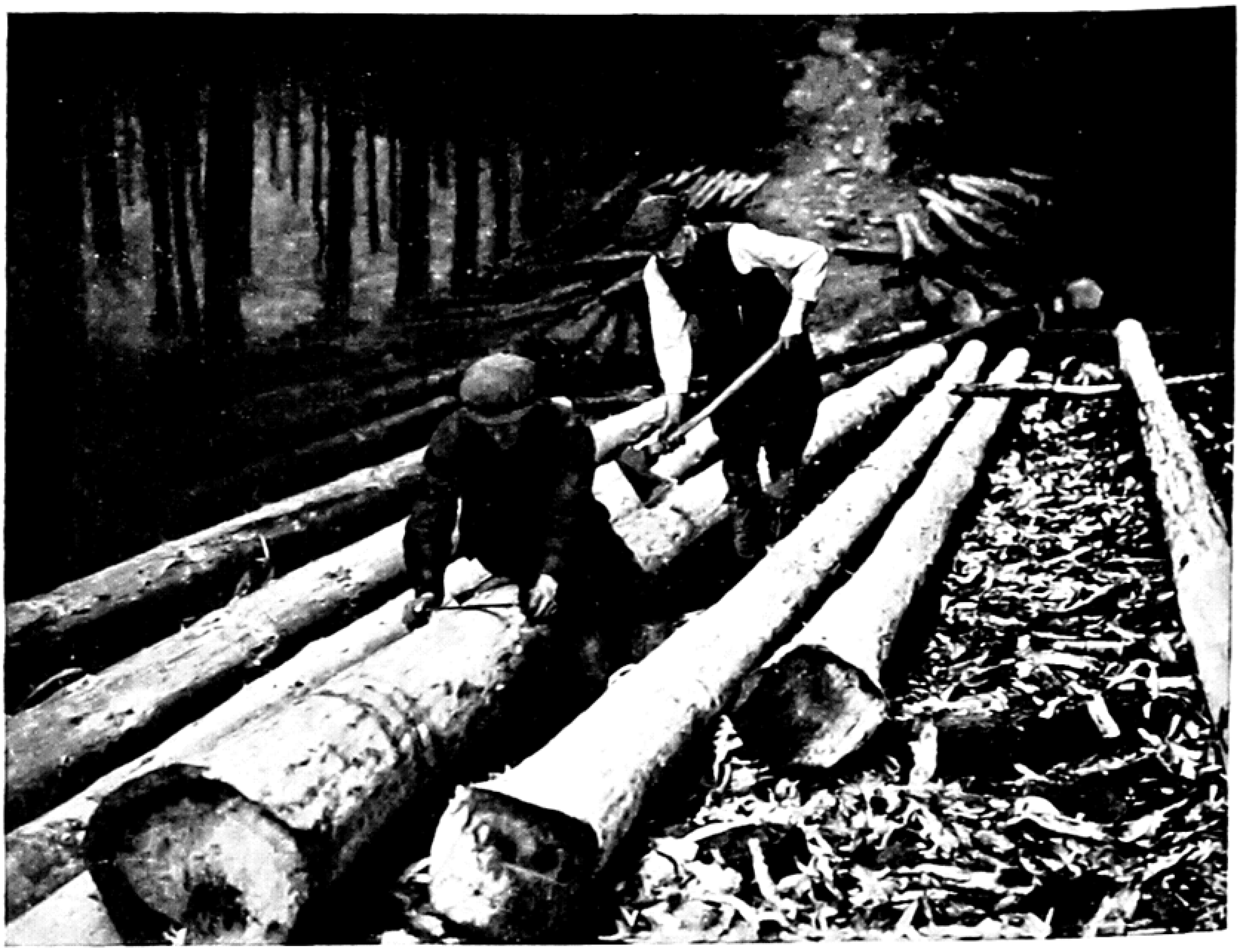
CLEAVING is the splitting of poles or logs lengthwise along a radius or diameter. Timbers vary widely in their capacity for cleaving without breaking or " running-out " to one side. Oak, Sweet chestnut, and Douglas fir cleave freely; elm is often uncleavable. Cleft material is cheaply prepared, and extremely durable; for wood cells along the line of cleavage are forced apart instead of being cut through (as by saw), and the resulting smooth



158 SAWING POLES INTO PIT-PROPS AT THE MANCHESTER CORPORATION FOREST ABOVE THIRLMERE RESERVOIR, CUMBERLAND



159 A CRAWLER TRACTOR HAULING PIT PROPS FROM A CLEAR FELLING OF CONIFERS



160 PEELING TELEGRAPH POLES TO PREPARE THEM FOR CREOSOTING

WORK IN THE WYE VALLEY WOODS, TINTERN, MONMOUTH surface has no weak points for moisture and decay to gain entry (107).

CLEFT OAK. The most usual form in which cleft oak poles find a market is as fencing stakes. Thinnings below timber size, clean-grown, and fairly straight, and from six inches to a foot in diameter, are used. After felling, they are cross-cut to the length required. The cleaving should follow closely on the actual felling; it is easiest in summer when the sap is up. A usual length is six feet, and each six-foot billet is first split in half lengthwise by inserting an axe blade along a diameter at one end. The split so formed is widened with wedges, splitting the billet into two half-cylinders. From each half-cylinder, further segments are then split off. Each is trimmed up with the axe and then pointed. This craft calls for skill, but can be mastered by most woodmen. Cleft stakes or " piles " are prepared and sold by the piece, and often provide a profitable outlet for oak of this class. The grades of stoutness are gauged by the " face " or side of the stake, which represents the radius of the log from which it was cut; a usual face is about four inches.

Cleft oak rails, six, ten, or more feet in length, demand greater skill in preparation; whilst few craftsmen remain who can cleave narrow palings for fencing, or shingles for roofing. Other uses of cleft oak are ladder rungs, staves for barrels, struts for supporting fence-posts, and some types of hurdles.

CLEFT CHESTNUT. As it has the durability of oak, but carries less sapwood, Sweet chestnut can be used in much smaller dimensions as a cleft material. The commonest form is as wire-bound fencing, for which coppice-grown poles are most frequently employed.

POLES AS A RAW MATERIAL

Poles which find no sale for use in the round, turning, or cleaving, either because they are intrinsically unsuitable or because no local market exists, are none the less a useful raw material for certain industries. They may be used for pulping, for breaking up into fibrous material, as firewood, or for charcoal burning.

BRANCHWOOD

The disposal of the tree-tops, crowns, or branchwood, is a minor problem arising from every tree-felling. As a rule, the purchaser of the timber is required to deal with it, under the terms of his contract. The thinner branches may be burned at small cost as the felling proceeds. The stouter material finds various uses, but the cash return seldom exceeds the cost of preparing for sale. It is therefore the custom for the purchaser of the timber to obtain the branchwood for nothing, or at most a very nominal charge, provided he undertakes to remove it within a certain time; should he fail to do so, he may be required to compensate the seller.

As a rule, branchwood must be removed before planting can be begun on the woodland area, for it harbours rabbits, insect pests, and harmful fungi, and may be a serious source of fire risk. Further, it encumbers useful ground, and makes weeding and the control of brambles, etc., very difficult.

CORDING. The first step in the disposal of large branchwood is the building up of *cords*. A cord is an oblong stack of short billets, usually 8 feet long, 4 feet high, and 4 feet through. Dimensions vary with locality, but most cords put up in Britain have a nominal volume of 128 cubic feet. The actual volume of timber present is about half that, the rest being air space. A cord weighs rather more than a ton, depending on species, length of seasoning, and tight-ness of stacking. No piece of branchwood in a cord should exceed 4 feet in length, and therefore there is a great deal of cutting as well as stacking to be done. Stacking must be done carefully and closely; loosely-stacked cords contain more air space than timber, and fetch low prices.

FIREWOOD. The bulk of branchwood or *cordwood* is used as firewood. Some users prefer to take it as it is, and do their own sawing up; but most consumers like to take it ready-sawn. This adds to the costs of preparation, and is usually undertaken by firewood merchants rather than woodland owners. Where the owners convert the logs, the branchwood may be stacked in the length, so saving the cost of cording. Though coal is the main fuel throughout Britain, logs are still preferred in many households for domestic heating, and there is a steady, if comparatively small, market for them. Fuel prices vary, but the cost of logs, considering their heating power, compares reasonably well with that of coal, and they are pleasanter and cleaner to use. All our common timbers will burn, but some require long seasoning to reduce their water content. Ash, beech, birch, hornbeam, sycamore, oak, holly, apple, and cherry may be ranked as first-class firewoods, and nearly all the coniferous woods burn freely when really dry. Sweet chestnut, elm, Turkey oak, and larch are less popular, being apt to throw sparks and splutter as they burn. Alder, willow, and poplar all rank as poor firewoods, owing to their high water content, unless well seasoned.

Branchwood is also used as kindling for fires, the small resinous side branches of conifers being most effective.

CHARCOAL BURNING. Another important use for branchwood is as charcoal. This is produced by burning wood with insufficient air for its complete combustion. The more volatile constitutents, such as hydrocarbons, are either burnt or driven off as gases; the solid carbon, and a little mineral ash, remain (162).

The ancient method of achieving this end was to make a dome-shaped stack of branchwood, cover it over with sods and earth, and leave a few inlet flues at ground level, with one outlet flue at the top. Great skill was needed to build a stack which would char well and evenly without collapsing, and to start the fire down in the heart of it. After the fire had got under way, and the wood near the core had been burned and to some extent destroyed, the inlet flues were gradually closed. The remaining wood then received insufficient air for its complete combustion, but sufficient heat remained to force out the volatile matter as gases, leaving the carbon content behind. This took several days to complete, and all the time the charcoal burner had to stay beside his *kiln*, watching it every few hours for fear a sudden collapse of its earthen covering might admit too much air and so cause the whole stack to disappear as a huge bonfire.

Stopping the process was even more tricky than starting it off. Any sudden inrush of air before the stack was quite cold would cause the whole stack to catch fire. First the slow fire had to be extinguished by closing *all* the flues, which was done soon after a change in the colour of the smoke from white to blue showed the charcoal burner that the right stage had been reached. Then the stack was allowed to cool off for two or three days, being watched the while, whilst the burner filled in the time by building his next stack. Then it was opened, somewhat gingerly, and if it had cooled sufficiently, it was unpiled. As a rule, water was added to ensure safe cooling.

This difficult craft was pursued out of doors throughout the summer months. Any mistake meant that a whole stack was destroyed, or had to be laboriously rebuilt. Latterly the trade has found few apprentices, and is now virtually extinct, though it survives in a few districts of Kent even in 1946. Charcoal burners lived a lonely life, for they could not leave their work by day or night. Yet charcoal was a staple fuel for domestic hearths and ironworks before the use of coal became general. All the bronze, iron, glass, and precious metals of the ancient and medieval craftsmen were refined by its use.

Modern charcoal kilns are made of metal, and are circular, with dome shaped covers and stove-pipe flues. They are portable, and are worked by trained men in sets of four kilns or more. Skill is still needed in their manipulation, and they must still be watched by day and night. But the risk of failure has largely been eliminated. The steel walls serve the same purpose as the old-fashioned sods and earth—they limit the access of air to the slowly-burning wood.

Charcoal is used in modern chemical and metallurgical processes, such as steel making. It is a highly divided and fairly pure form of carbon, and as such is employed in artificial silk and rubber manufacture, and in paints and varnishes. It is also a constituent of gunpowder. Faulty manufacture affects its purity by leaving too much volatile matter or giving too high a proportion of mineral ash; the aim is to get the highest possible content of pure carbon. Charcoal is also used medicinally, in gas masks, and in poultry foods, whilst the ash found at the bottom of the kilns is a fertiliser rich in potash; as a fuel, it still finds employment in the drying of hops.

WOOD DISTILLATION. Wood can be heated in retorts, in the same way as coal is treated in gas manufacture, with analogous results. The solid matter which remains consists of charcoal. The volatile products that are driven off, chemically treated, and purified, include tars, wood oils, acetic acid, naphtha, and methyl acetate. The great advantage of distillation is that it enables all these products to be recovered, whereas with ordinary charcoal burning they are burned or dissipated. The process has been highly developed abroad, as a means of utilising branchwood; but as yet there are few British forests large enough to ensure steady supplies of such wood for the large factories which are required to render the distillation economically worth while. Resin and turpentine may be obtained by distilling coniferous timbers.

BRANCHWOOD AS A RAW MATERIAL. Some types of branchwood, such as that of pines of mature age, or of birches, are a suitable raw material for pulping and similar disintegrating processes.

COPPICE MATERIAL

The produce of coppices, and also that of the *pollarded* trees that are periodically cut back a few feet from the ground, is utilised in ways which vary with the kind of tree, including those listed below.

Alder: Turnery poles. Charcoal. Carving clog soles.
Ash: Poles for tool handles. Hurdles.
Beech: Turnery poles. Firewood.
Birch: Turnery poles. Firewood. Pea-sticks. Besoms.
Sweet Chestnut: Bean rods. Fence stakes. Hop poles. Cleft-pale fencing. Walking sticks.

Hazel: Pea-sticks. Bean rods. Faggots for bakers' ovens. Cleft rods for hurdles and thatching spars. Round rods for crate making and heading. Rods for revetment work. Fascines.
Hornbeam : Firewood. Pea-sticks.
Lime: Turnery poles.
Field Maple: Fence stakes.
Oak: Cleft poles. Fence stakes. Firewood. Hurdles.
Poplar: Rough basketry. Hurdles.
Wild Cherry: Turnery poles.
Willow: Basketwork of all kinds. Hurdles.

The appropriate rotation, or interval of years between each cutting, varies with species, uses, and markets. Some willows are cut yearly, but oak and chestnut coppice may stand for as long as 15 years. Coppice material may either be sold as it stands, by the acre, or converted and the produce sold by the piece. Some of the items listed above call for special mention.

HURDLES. The weaving of wattle hurdles is a woodland craft requiring great skill. Several kind of coppice are used in different districts. Hazel is cleft with the billhook before weaving, but willow is sometimes used in the round. The rods are interwoven in such a way that the whole structure holds itself together without nails, ties, or wire, forming a light yet robust wooden screen. Hurdles are chiefly used for folding sheep or sheltering gardens (106).

PEA-STICKS. Cut preferably in winter, before the leaves are out, pea-sticks average 5 feet in length, are sold in bundles of about 25, and must be very branchy; they are only saleable during spring.

FAGGOTS. Bundles of branchwood, about 6 feet long by 2 feet through, used by bakers in rural districts to heat their ovens (105).

FASCINES. Similar bundles of stouter rods, used in road and dock construction in marshy ground, as a lasting support for heavier foundations which would otherwise sink through the mud.

REVETTING RODS. Long rods, 10 feet or more by about an inch thick, used together with stakes to support the sides of trenches, etc.

CRATE RODS. Flexible rods of various sizes, chiefly hazel, are bent into semi-rigid crates for packing pottery, as their springiness absorbs sudden shocks.

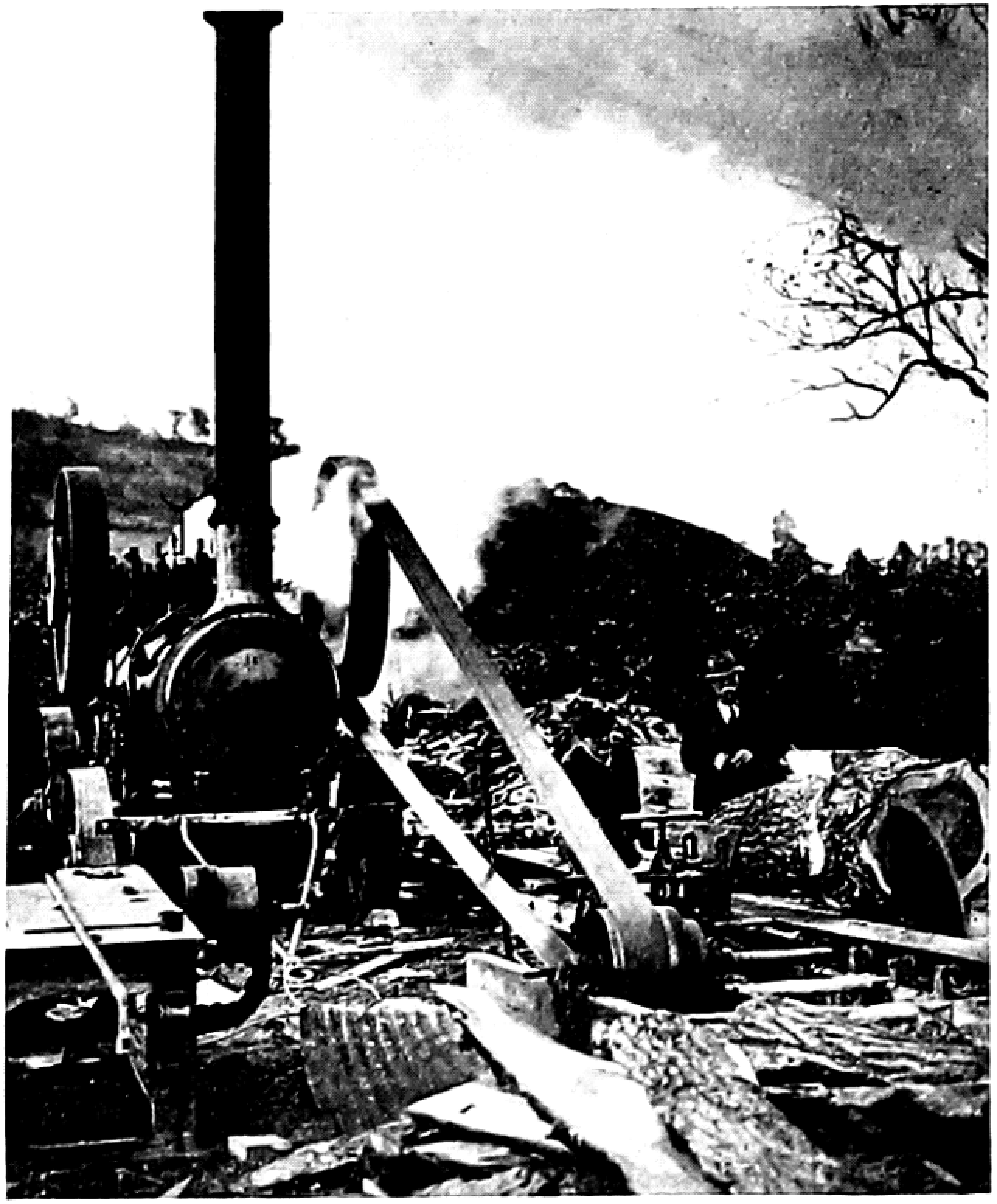
CRATE HEADING. Stouter, rigid rods, used to form the framework of crates for glass bottles, etc.

Other curious uses for coppice rods include the making of fenders to shield the sides of ships from collisions with dock walls, and the construction of salmon traps and lobster pots.

BASKETWARE. The basket trade requires coppice material, chiefly willow, grown specially to its requirements. Rough baskets are made with the bark still on the twigs, but for finer work the willow rods are first steeped or boiled in water and then peeled. Material of various sizes and varieties of willow or osier is used for different grades of work.

THATCH SPARS OR GADS. Thin lengths of cleft hazel, whole willow, or similar material, used to tie straw thatch on to house roofs, hay ricks, and corn stacks. Required in quantities by farmers at harvest time, these are usually prepared and sold by the bundle of 50 or 100 spars.

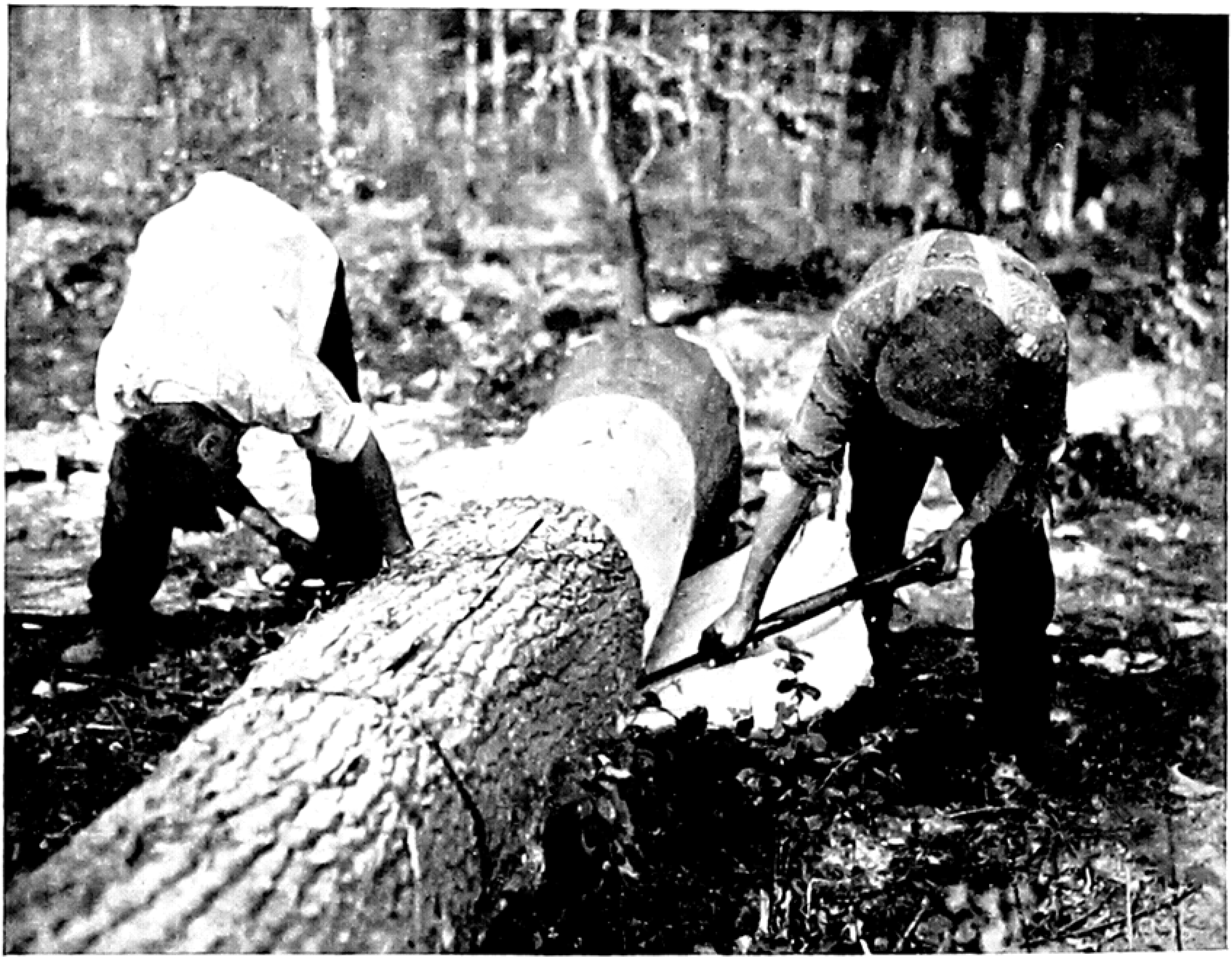
Coppice utilization varies from one district to another. It pays the forester



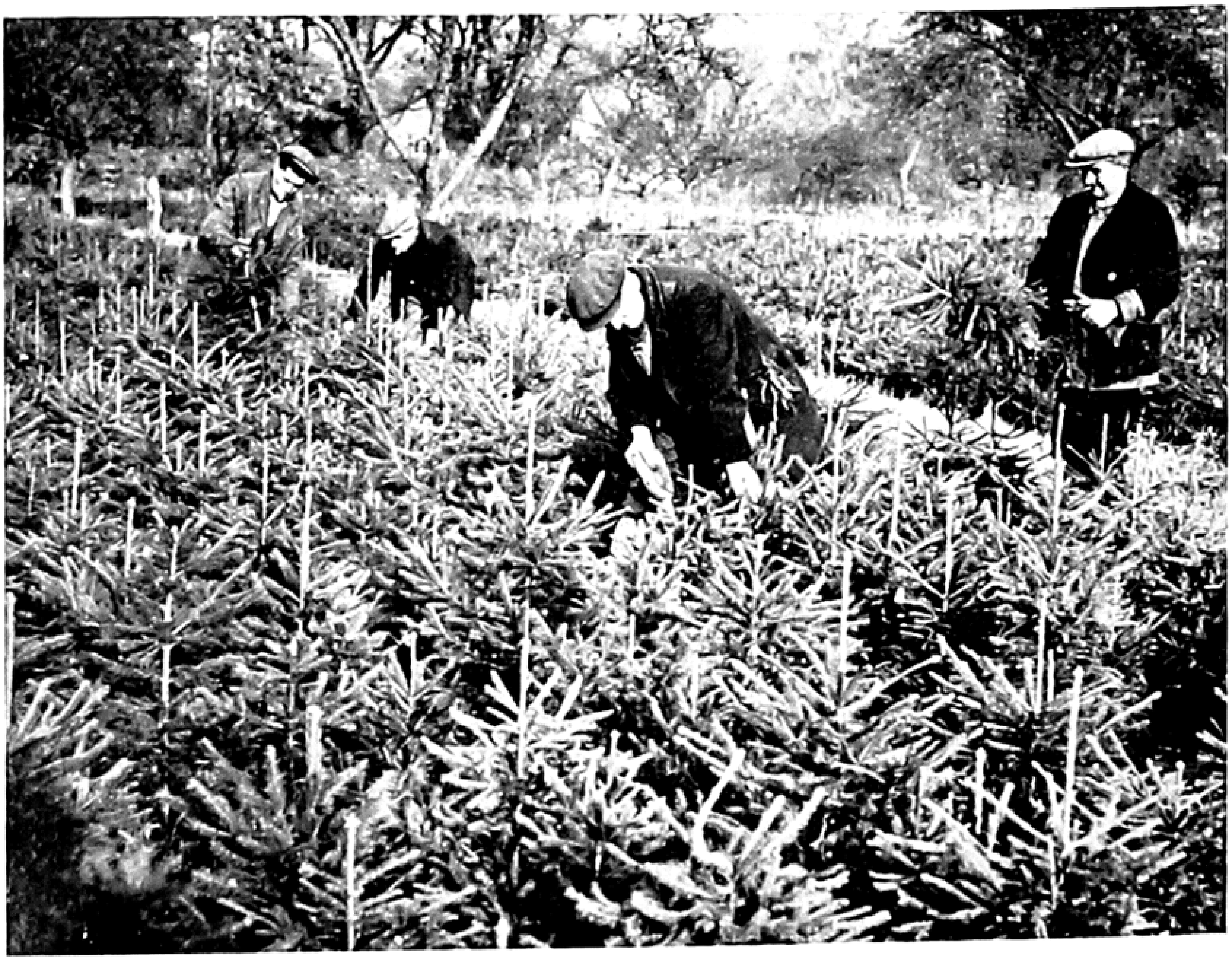
161 A TRAVELLING STEAM MILL SAWING UP ELM LOGS

162 CHARCOAL BURNERS, TENDING A BURNING KILN AND BUILDING A NEW ONE

OLD-FASHIONED WAYS OF USING WOODLAND PRODUCE



163 STRIPPING OAK BARK FOR THE TANNERIES



164 LIFTING NORWAY SPRUCE FOR CHRISTMAS TREES

well to study local usages, for even where it does not pay to continue to grow coppice as such, it may prove possible to clear an existing crop at a profit, and so free the ground for other forms of plantations.

MINOR PRODUCE

There are a number of other forest products that occasionally serve a useful purpose and bring in a monetary return. Some are produced by trees, whilst others occur on forested areas owing to the peculiar natural conditions that prevail there.

SEEDS. Forest tree seeds are an important forest product, and the collection of the commoner kinds has been briefly described under the heading of " Nurseries " in Chapter 14. Not only are they essential for the production of future forests, but they have a market value, being purchased as required, at the rate of so much per pound for broadleaved trees, or so much per bushel for cones, by nurserymen and seed merchants.

EDIBLE FRUITS. A cash return may sometimes be obtained for woodland crops of Sweet chestnuts or hazel nuts; these can be sold at so much a pound, or else the right to collect them may be leased out. Other wild fruits, too little in demand for a regular market, but gathered occasionally for making jams, jellies, or beverages, are crab apples, rowanberries, elderberries, sloes, and wild cherries. The undershrubs of the forest produce edible fruits such as raspberries, blackberries, wortleberries, Black and Red currants, and wild gooseberries, whilst wild strawberries are abundant in forest clearings on chalk areas.

Another random harvest of the woods is the gathering of edible fungi, including the rare but delicious truffle; but experts in the selection of the nutritious kinds are few, and it is not a safe field for experiment!

HERBS. Forest land is often rich in officinal plants and herbs, such as foxglove and belladonna leaves, broom shoots, Horse chestnut bark, Male fern fronds, and wild rose hips. These are sometimes collected for the use of manufacturing chemists and herbalists, as are other rural remedies with less recognition in conventional medicine.

MAST FOR PIGS. Pigs may be fattened on acorns, beech nuts, and sweet chestnuts, which may be collected for them, or else the beasts may be allowed to search for them in the woods.

GRAZING. Although there may sometimes be a crop of grass in the forest glades, the grazing of domestic animals is invariably accompanied by so much damage to the forest soil and young trees, that no prudent forester will permit it.

TREE SEEDLINGS. Natural seedlings trees are sometimes dug from the forest, if they grow too thickly or where they are not required, and used or sold for transplanting in new forests or nurseries. This is sometimes successful with hardwoods, but rarely so with coniferous trees, and it is generally preferable to raise young trees in nurseries.

CHRISTMAS TREES. Norway spruce trees, from 2 to 10 feet high, find a sale at good prices around Christmas time. As a rule they are raised for the purpose in special nurseries, but surplus trees from the forest may be disposed of in this way (164).

FOLIAGE. Florists buy large quantities of evergreen foliage, chiefly for making wreaths. Lawson cypress and thuya, amongst the conifers, are valued because their foliage does not fall, and their brashed side branches may be profitably disposed of in this way; laurel is also in demand. Near Christmas time, too, the forest may yield its supply of berried holly and mistletoe.

As in the case of fruits, there is an uncommercial harvesting of beauteous foliage and berries from the woods, both in spring and autumn. The tender emerald green of newly-opened larch or beech leaves is gathered at the same time as the bluebells. Later comes the garnering of pink-and-orange spindle berries, which blend their colouring with the russets of the fall.

LEAF LITTER. Dry forest leaves, such as those of the beech, are sometimes sold by the sackful as litter for poultry houses and similar purposes.

LEAF MOULD. This can be a useful source of forest revenue, for nurserymen will often take it by the load for use in potting composts and as a component of garden soil. Its removal takes away a certain amount of fertility from the soil, so that the owner should weigh the *pros* and *cons* before parting with it. One good use is in the home forest nursery, for fertility returns to the woods in the form of sturdier forest trees. Beech mould is the best, and old beech woods appear to produce enough of it to stand its removal, in moderate amounts, without ill effects.

TANNING BARK. Before the advent of chemicals and imported wood extracts, oak bark was a customary tanning agent, and it is still used for certain high-class work. It is stripped from the felled log, or occasionally from the standing tree just prior to felling. Unless the sap is running the bark will not strip, even though the special tools are available for the work; the season from April to July is most favoured. The strips of bark are stacked in the woods to dry out before being despatched to the tanneries (163).

Other hardwood barks, such as alder; and some conifers, such as hemlock; are also effective tanning agents, but are rarely in demand.

RESIN AND TURPENTINE. These may be obtained from many conifers, either by *tapping* the living tree by cutting into its sapwood with sharp tools, or by distilling the woody tissues after felling. They are used chiefly for making paints and varnishes. Resin tapping is a big industry in the south of France and the south-eastern States of North America, but has never been developed in Britain; the best resin-producing pines are rare in our woods.

MOSS. Forest mosses are used by florists, and also as a packing material, particularly for garden plants that have to be bundled for despatching.

BRACKEN. This may be cut in autumn from forest rides for use as bedding for stock, or as packing material for young trees. It should never be cut in plantations, for the scythe is bound to damage the young trees.

HEATHER. Used for road-building on marshy ground, as a foundation layer for gravel. Also as a thatching material, and in brooms. Sold by the load.

HONEY. Stocks of bees are sometimes moved for the season into forest areas rich in nectar-bearing flowers, such as heather.

GAME. Game of all kinds thrives in or near forested land. Deer, rabbits, pheasants, partridges, grouse, wood-pigeons, and wild duck find either food or shelter in the woods, and even fish are said to teem more plentifully where the rivers flow from or through woodlands. The sporting rights over forest land are consequently of value, whether used by the owner or leased out to others. As a rule, a balance can be struck between game preservation and good forestry, for most animals and birds, except the rabbit, do little harm to the trees if their numbers are kept at a reasonable figure.

CHAPTER 20

THE MEASUREMENT OF TIMBER, TREES, AND FORESTS

The timber content of forests requires measurement from time to time for such purposes as sale, valuation, and general management. It is often necessary to know how much timber is standing in each plantation, and to ascertain how fast its volume is increasing from year to year. The methods of measurement adopted by scientific investigators are highly accurate, but involve complex mathematical formulae, and much simpler methods are commonly used in Britain by foresters, timber merchants, land agents, and valuers. Timber can be measured accurately, in the strictest sense, only after it has been felled. All measurements of standing trees and forests are therefore *estimates*.

The steps involved in estimating the timber content of a whole forest can best be explained by considering firstly how sawn timber and round logs are measured, next how a felled tree is dealt with, then how a standing tree is assessed, and finally how whole plantations and forests are measured up.

MEASURING SAWN TIMBER

Sawn timber is nearly always measured and sold by volume, rather than by weight. This is because it is both bulky and heavy, and therefore more easily measured in terms of its dimensions than weighed; also because during the process of seasoning its weight decreases a great deal, whilst its volume continues almost unchanged, decreasing only very slightly. For certain purposes, timber is customarily measured in terms of its area, e.g. as so many " squares " of 100 square feet each, but as the thickness is also specified, a simple calculation will give the *volume* involved, and the unit is therefore, in effect, a volumetric one. The same applies to the sale of sawn timber by the " foot run "; at first sight this looks like a linear measure, but as the width and thickness are both stated in order to define what is intended, it again becomes merely a form of expressing a certain *volume* of material.

The key unit for measuring all *sawn* timber in Britain, is the *true cubic foot*, measuring one statutory linear foot in each direction. Other units derived therefrom are used for special purposes, but all can be expressed in terms of true cubic feet by appropriate calculations. For example, the *Petrograd Standard* of 165 cubic feet, is the customary unit for imported sawn timber. The *foot super of one inch thickness* is used for certain hardwoods; this is one-twelfth of a true cubic foot, and is equivalent to the *board-foot* used in North America.

The cubic content of any regularly-shaped piece of sawn timber is obtained as follows:

Multiply the length in feet by the breadth in inches, and multiply the product by the thickness, also in inches. Divide the result by 144, to obtain the volume in true cubic feet.

The formula is therefore:

$$\frac{\text{Length (feet)} \times \text{Breadth (inches)} \times \text{Thickness (inches)}}{144} = \begin{array}{c}\text{Volume}\\ \text{(cubic feet)}\end{array}$$

Such calculations can obviously be greatly simplified by the use of tables, or " calculators," and these are used by timber merchants, quantity surveyors, and other estimators who have to deal with large quantities of sawn timber every day.

As an example, to find the volume of a board 12 feet long, 24 inches wide, and 2 inches thick, multiply 12 by 24 and the result (288) by 2 to get 576. Divide this by 144, and the answer is *4*, which is the volume of the board in true cubic feet.

As few numbers are exactly divisible by 144, this division should be done in stages of 12 and 12. The remainder, if any, from the first stage consists of " parts," small units which are usually ignored. The remainder from the second stage is composed of customary " inches," so called because each of them is one-twelfth part of a cubic foot. These " inches " are duodecimal fractions, but are usually written down as though they were ordinary decimals. Thus, 2·6 cubic feet, on a timber man's record, usually means 2 cubic feet plus 6 " inches." (This is two-and-a-half cubic feet only, *not* two-and-six-tenths cubic feet.)

These customary " inches " must not be confused with true cubic inches; a little reflection will show that each of them is equivalent to 144 true cubic inches. Furthermore, they do not precisely coincide with the *Hoppus* inch which is discussed in the next section, as that is a measure of round timber.

The measurer of sawn timber has a curious name for a true cubic inch, which is one twelfth of his " part," and one one-hundred-and-forty-fourth part of his " inch." He calls it a " second." There are 1,728 " seconds " in one cubic foot.

MEASURING ROUND TIMBER

The unit generally used in Britain for measuring round logs, trees, and plantations, is the *customary* cubic foot, or *Hoppus* foot, calculated on the *quarter-girth* system. This is a measure of the useful timber content of each log or tree, rather than its precise cubical volume.

Alternatively, the true cubical contents of the round timber, whether felled or growing, may be calculated by more scientific methods; but the *Hoppus* system suffices for most purposes of sale, valuation, and management. For its results bear a reasonably consistent relationship to the figures obtained by more precise means.

The *Hoppus* measure of any round stem is easily calculated by a simple formula, made even easier in practice by the use of a special measuring tape, and a set of tables. These are called *Hoppus* tables, after their originator.

MEASURING FELLED LOGS. To measure a felled log, that is a portion of a felled tree which is fairly regular in shape, its length in feet is first obtained with a tape measure. Then it is *girthed*, by passing a tape measure around its circumference at the mid-point of its length. Thus, if a log were found to be 10 feet long, its girth would be taken at the point 5 feet from each end. This girth is measured in inches, and the result is divided by four to obtain the *quarter-girth* (see figure 165).

To save the arithmetic of dividing by four, a "quarter-girth tape" may be used. This is calibrated to read, on one of its sides, four inches as one inch, and so on for all measurements in like proportion.

Whether the quarter girth is obtained by measuring the true girth and dividing, or by the quicker method of using a quarter-girth tape, the next step is to *square* it. Squaring is the simple mathematical process of multiplying any given number by itself.

The "square of the quarter-girth" so obtained, is then multiplied by the length of the log in feet, which was found at the very first measurement. The product or resulting figure is then divided by 144, and the answer is the volume of the log in *Hoppus* cubic feet.

This last stage in the calculation is likely to leave a remainder, since few numbers can be divided exactly by 144. But the system allows for this contingency; division by 144 should be carried out in two stages; first divide by 12 and then by 12 again. The remainder from the first step consists of *Hoppus* "parts," each equal to one one-hundred-and-forty-fourth part of a *Hoppus* foot. The remainder from the second step consists of *Hoppus* "inches" each equal to one twelfth part of a *Hoppus* foot, or to 12 *Hoppus* parts. (These are rather peculiar "inches," and must never be confused with true linear, square, or cubic inches.)

Unless the timber is very valuable, the little "parts" are generally ignored, and so the volume of the log is stated as so many *Hoppus* cubic feet, so many *Hoppus* inches. It is the custom to express the latter item as though it were a decimal; so the entry "*15·11*" in a timber-measurer's notebook does not indicate that his mathematics have gone awry or become unduly complex, but simply that he has measured a log with a cubic content of fifteen and eleven-twelfths (or eleven inches) *Hoppus* cubic feet.

As an example, if a log is 16 feet long and the girth at its mid-point (8 feet from each end) is 40 inches, its mid quarter girth will be $40 \div 4 = 10$ inches. This may be found with an ordinary tape measure, which would read "40," and then dividing by 4; or with a quarter-girth tape which would read the same girth as "10" direct.

This figure is squared, thus: $10 \times 10 = 100$. This result is mutiplied by the length of 16 (feet), so: $100 \times 16 = 1{,}600$. This is divided by 12 to give 133 plus a remainder of 4; the "4" represents "parts" and may be ignored. Divide again by 12 to get 11 plus a remainder of 1. The volume of the log is therefore 12 *Hoppus* feet, 1 *Hoppus* inch, and may be written as 12·1 *Hoppus* feet.

The formula for the *Hoppus* measurement is:

$$\frac{\text{Length (feet)} \times \left\{ \frac{\text{Girth (inches)}}{4} \right\}^2}{144} = \text{Volume (Hoppus feet)}$$

There are only two variables for this formula, that is the length and the girth. Therefore a simple set of tables can be drawn up, to express the volume of any log of which the length and (quarter) girth are known.

In practice, then, all the calculations described above are effected by the use of tables, and all the timber measurer has to do is:

(a) Measure the length of the log in feet.
(b) Measure its quarter-girth at mid-point in inches, by means of his quarter-girth tape.

(c) Look at the appropriate point in his tables to read off the volume of the log in *Hoppus* feet and inches.

The simplicity and speed of this system, together with its comparative accuracy, have led to its general adoption by those who have to deal with timber in the round.

HOPPUS MEASURE, TRUE MEASURE, AND BOARD MEASURE. Hoppus measure does not set out to represent the actual true contents of a round log. It shows instead the quantity of squared timber which a careful sawyer is likely to obtain from it. This is the figure in which the buyer is most interested, for he knows that about one quarter of the total volume of each log will be discarded as waste in the form of slabs or offcuts, or as sawdust.

The *true measure* of a log is calculated on the assumption that its form is an evenly-tapering cylindrical solid. The ratio between true measure and Hoppus measure is a constant. 113 Hoppus feet equal 144 true cubic feet. The Hoppus measure is an *understatement* of the true volume of a log. If it is desired to convert it to true measure, this can be done by multiplying by 1·273. Hoppus measurements therefore give data which can be converted by simple factors to the needs of scientific foresters; whilst true measure, scientifically computed, can be adapted if required to the purposes of timber marketing, by multiplying by ·7854 to give its value in Hoppus units.

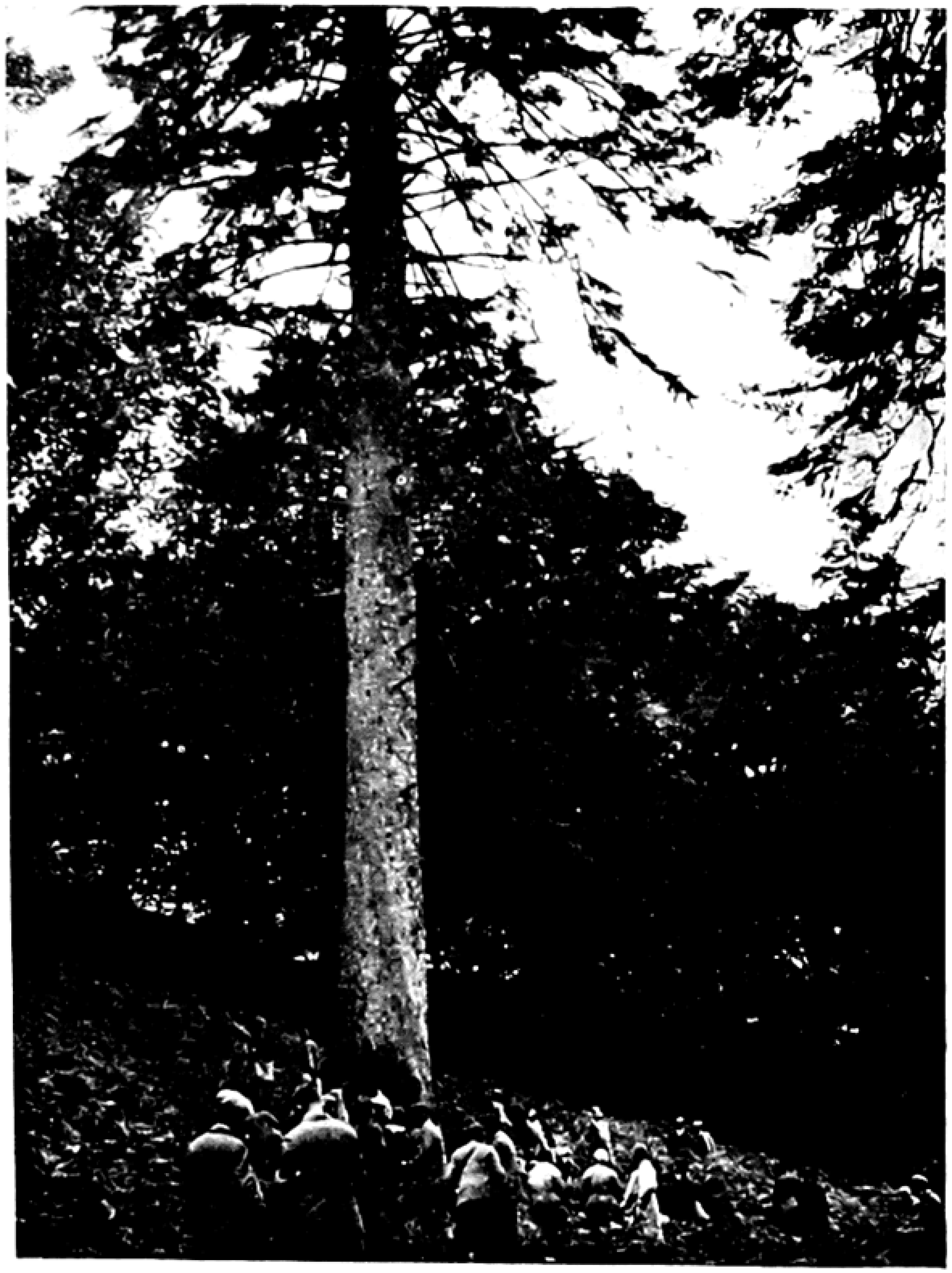
On the continent of Europe, true measure is generally used, the basic unit being the cubic metre. Such measurements can also be converted, if required, to the Hoppus system, and *vice versa*.

In North America, what is known as " board measure " is used. Its basic unit is the *board foot*, one foot square by one inch thick, equal to one twelfth part of a *true* English cubic foot. The contents of a log are expressed as the number of board feet which can be sawn out of it. This is calculated by tables known as *log scales*, which correspond to our Hoppus tables. However, there is no one generally accepted scale, and different volumes are given for the same log by the use of various scales, all reputedly accurate. For example, some scales assume a greater wastage in sawing than do others. The Hoppus measure used in Britain is known and understood throughout this country, whereas American foresters have to contend with systems of measurement that vary from one state to the next.

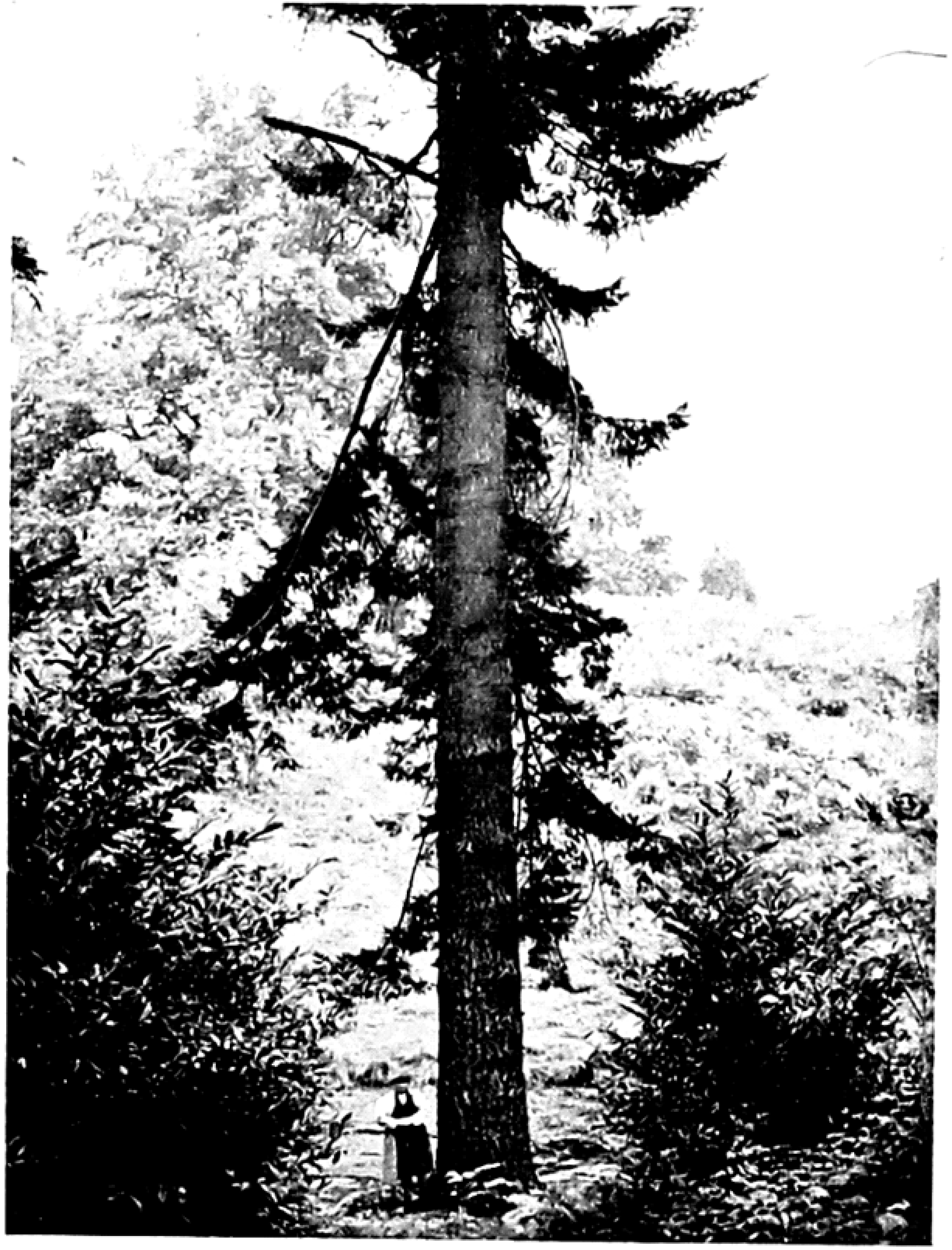
BARK ALLOWANCES. If a log is measured after the bark has been removed, no allowance has to be made for it, as only actual timber is covered by the girthing tape. But most logs are measured out in the woods with their bark still on, so a deduction is made from their Hoppus measurement to allow for this. As a matter of convenience, a certain percentage deduction is made for each kind of tree. The usual figure for all coniferous trees in England is 7½%, but in Scotland the timber merchants insist on a higher figure of 10%. One suspects that when a free market obtains, the Scottish timber grower raises the price of his material a trifle, because he is not paid for the bark, and it is inequitable for him to suffer a larger deduction than his English neighbour.

For hardwoods, the percentages in both countries are the same; i.e. 7½% for ash, beech, birch, and sycamore, 15% for alder, elm, lime, and poplar, and 10% for oak, Sweet chestnut, and other common hardwoods. These distinctions are purely arbitrary, as is that between England and Scotland in the case of conifers. If actual measurements are made, the percentages of bark

165 GIRLS OF THE WOMEN'S TIMBER CORPS MEASURE THE LENGTH AND GIRTH OF A FALLEN PINE



166 BIGGEST IN BRITAIN: SILVER FIR, KILBRIDE, ARGYLL; 168 FEET HIGH, 20 FEET 7 INCHES GIRTH (AT 5 FEET UP)



167 TALLEST IN BRITAIN: DOUGLAS FIR, POWIS CASTLE, MONTGOMERY; 175 FEET HIGH

FORESTERS EXAMINING TWO OF BRITAIN'S GREATEST TREES vary widely from one log to another, even when trees of the same species are grown in the same country.

Overbark measure is that obtained when the tree is girthed with its bark still on. *Underbark* measure results from making the appropriate deduction, or else from girthing a barked log.

MEASURING FELLED TREES

For measurement purposes, felled trees are divided up into the number of useful lengths which they contain, and each length is treated as though it were a log, and measured in the way described above. Thus, a small tree of simple shape needs only one measurement, and the only point to be decided is the position of the end of the tree for timber purposes. Obviously, a tree cannot rank as timber to the very tip of its trunk, and the point where timber is deemed to cease is termed its *timber-point*. This is usually where the log tapers down to 3 inches diameter, over-bark measure. The tip beyond this timber-point is ignored entirely in calculating the volume of the tree. The height of the tree, i.e. the length of the felled log, is termed the *timber height*, and is of course nearly always less than the total height of the tree.

If a tree tapers unevenly, it is divided into portions which are measured separately, and the results are then added together to obtain the total volume of the tree. The points at which the divisions are made, usually where large branches are thrown off, are termed *stops*.

Branchwood too small for sawing is ignored, being treated as cordwood, and measured as an entirely separate item. But any branch big enough to rank as timber is treated as a separate log, and its volume added to the whole. A forked tree, Y-shaped, is usually treated as three logs.

MEASURING STANDING TREES

Standing trees can only be measured accurately by climbing up them to ascertain their timber height, and their girth at mid-point, with a tape measure. This would be slow and costly, and is quite out of the question when thousands of trees have to be measured.

Consequently it is the custom to *estimate* the volume of standing trees from their apparent height and mid quarter-girth, as seen from the ground. Various scientific aids have been devised to assist the estimator, such as *hypsometers* which indicate the height to timber point with considerable accuracy. But the personal factor inherent in all estimates remains. No two estimators are likely to give the same volume for any given tree.

The height to timber-point is most frequently obtained, in practice, by placing a 20 foot pole against the tree, where it is held erect by an assistant. The estimator, standing well back from the tree, estimates its useful timber height from the proportion which it bears to the pole. Thus, a tree three times as tall will be 60 feet high.

The girth at mid-point can be estimated by girthing the trunk at breast height, where it can easily be reached, and allowing for the *taper*, or amount by which the trunk decreases in girth, between that level and the mid-point. All trees taper as they ascend, but in very varying degrees; the girth at mid-point is bound to be less than that at breast height; how much less is a matter for the estimator to decide; It will vary from one tree to the next, but average degrees of taper may be ascertained by examining any felled or wind-blown stems that are available. " Breast height " is 4 ft. 3 ins. above ground level.

Once timber height and girth at mid-point have been estimated, Hoppus tables are applied in the usual way to obtain the volume, (after reducing the girth to its quarter-girth equivalent by dividing it by four.)

Crude though this method is, it gives reliable results in the hands of experienced woodmen, particularly if they are able now and again to check their estimates against the actual measurements of felled trees. Some of them, indeed, will undertake to estimate the volume of a standing tree on sight alone, without taking any measurements at all.

Refinements, too complex for simple explanation, are utilised by scientific students of tree growth, but even they resort to felled trees to test the accuracy of their estimates.

MEASURING A PLANTATION

There are many methods by which a plantation of standing trees, all of the same age and type of growth, may be measured, but the three that are simplest and most easy to understand are:

1. Measuring every tree, and adding the volumes so obtained to get the total volume.
2. Counting every tree, measuring a reasonable number of trees selected as *samples*, and calculating the volume of all the trees, from the total volume of the *sample trees*, by a simple proportion sum.
3. Finding the *area* of the plantation, and then selecting a small portion of it as a *Sample Plot* (169). All the trees in this small plot are then measured, and their total volume found. The area of the Sample Plot is fixed by measurements made on the ground. Then by comparing this area with that of the plantation as a whole, the volume of the whole plantation can be calculated, by a simple proportion sum.

The first of these methods calls for no explanation. It is adopted wherever the timber is of very high value, or the number of trees small. But as one acre of full-grown timber often carries 200 stems or more, it cannot be used for large areas without undue trouble and expense. As each tree is measured it is marked, and its volume entered in a notebook.

The second method, that of the *Sample Trees*, is also useful on small areas, but difficult to apply to large plantations, on account of the numbers of trees involved. It is far from easy to count trees accurately in a large wood; the area must be broken up into sections or strips to avoid missing any tree or counting it twice. The sample trees must neither be too good nor too poor, but a fair sample of the crop as a whole. A simple method is to measure every tenth tree as the counting proceeds. The total volume of the measured sample trees is then multiplied by 10 to give the volume of the whole wood.

SAMPLE PLOTS. This is the most convenient method for large plantations. It is necessary to know the area of the whole plantation (or crop of trees of the same type and age), but this area is readily obtainable throughout Britain by reference to the series of maps of the Ordnance Survey that are drawn on a scale of 25 inches to 1 mile. These state the area in acres, and decimal fractions, of every piece or " parcel " of enclosed land. Therefore it is only necessary, in most cases, to find the plantation on the map in order to know its extent. Where the boundaries of the plantation do not coincide with the Ordnance Survey "parcel," it may be necessary to do a small amount of surveying on the ground, with a tape measure or a surveyor's chain of 22 yards length. The true outline can then be plotted on the map, and its area calculated from the scale of the map. This can be done by the ordinary rules for measuring areas, or with a planimeter, or with a transparent grid scale. More complex lay-outs, e.g. where many plantations have been formed on one large parcel of land, such as a moor, may call for skilled surveying; but the area of most of the older plantations in Britain may be found by careful inspections of existing published maps.

The next step is to determine the area to be adopted for the sample plots or plot. A handy area is *one square chain*, because it simplifies calculations and is easily laid out on the ground. It is defined as a square measuring 22 yards in each direction, and its area of 484 square yards is precisely equal to one-tenth of an acre. Therefore, if one can determine the volume of the trees on a sample plot of one square chain, it is only necessary to multiply the result by 10 in order to find the volume that is probably standing on each acre.

Sample plots must be chosen with care. If the quality of the timber crop varies, a proportion should lie in the better parts and a proportion in the poorer ones. The number necessary varies with the uniformity or variability of the crop, and with the degree of accuracy required, as well as with the size of the area. One square-chain plot per acre is often sufficient.

As each sample plot is chosen, its boundaries are marked with temporary posts and strings, and every tree within those boundaries is measured by the means previously described. The total volume for the plot is then found by addition, as is the total volume for all the plots if there is more than one. The total volume for the whole plantation is then determined by a simple proportion sum, as it is taken to be proportionate to the respective areas.

For example, suppose two sample plots, each one square chain in extent, are chosen in a wood which measures two acres. On one plot there are 30 trees averaging 10 cubic feet each, giving a total for that plot of 300 (Hoppus) cubic feet. On the other plot there are only 20 trees, but each averages 20 cubic feet, so the volume for that plot is 400 (Hoppus) cubic feet. The two plots together carry therefore 700 (Hoppus) cubic feet on two square chains. The whole wood is ten times this size, and so must carry 7,000 (Hoppus) cubic feet in all; or 3,500 cubic feet, Hoppus measure, *per acre*. (Hoppus measure is used for this example, but the same principles apply to true measure.)

MEASURING A FOREST

A forest or large woodland estate usually consists of many plantations which differ in their ages and the kinds of trees which make up their crops. For measurement purposes such a forest must be divided into its component parts, so that each can be measured up separately by the methods described above for a single plantation.

The first step is to survey the forest to find out the extent of each type of crop. The starting point of such a survey is the ordinary topographical map, on a scale of 25 inches to the mile, or 6 inches to the mile in the case of very large areas. On this the outlines of the different kinds of plantations can be marked after a thorough inspection on the ground itself. To make a clear picture, the map is often coloured up; coniferous crops are usually represented by various shades of brown, according to their ages, and crops of broadleaved trees by shades of red and blue. The resulting map is termed a *stock map*, and may be used as a basis for both measurement and subsequent management. At the same time the forest may be split up into areas of twenty to thirty acres, defined as far as possible by natural boundaries, which are called *compartments*. These are the units for management purposes, resembling the fields of the farmer.

Young plantations with little or no timber content can only be measured in terms of area. So a brief description of their age, species, and rate of growth, height attained, etc., is added. The whole account makes up an inventory or stocktaking of the forest, which can be preserved as a guide to future forestry operations. It is, in fact, the basis of a *working plan*, which is discussed further in the next chapter.

INCREMENT

If the volume of a plantation is estimated at a certain age, and again so many years later, it will almost invariably be found to have increased. The amount by which it has grown is called its *increment*. If this total increment is divided by the number of growing seasons which have intervened between the two measurements, the result represents the average yearly growth, or *annual increment*. In all such calculations account must be taken of the volume of the trees removed as thinnings between the two measurements; these often add substantially to the increment figures, forming a large proportion of the total timber yield. Annual increments are expressed as so many *cubic feet* (Hoppus or true measure) *per acre per annum*. They show how fast the crop is growing and help to indicate its likely total production of timber and the best age at which it should be felled.

Besides increment in volume, the forester is also interested in increases in height (height increment) and in the thickness of the tree trunks (girth increment). Increases in age, height, girth, and total volume of a tree crop are usually accompanied by *decreases* in the number of trees standing on each acre, as many are removed either by thinnings, accidents such as wind-blow, or disease.

YIELD TABLES

It is obviously useful to have the known data concerning the heights, girths, volumes, increments, and numbers of trees per acre, found by actual measurement of sample plots of trees of different kinds, assembled together in tabulated form. This is done by means of *yield tables*.

Such yield tables express the normal rates of growth of timber crops of various species of trees under varying conditions. Naturally these rates vary according to the quality of the soil, and other local factors, and with the country in which the crop is growing. The tables prepared on the continent of Europe are of little value when applied to British conditions, but the Forestry Commission has issued a series based upon the measurements of numerous sample plots in England, Scotland, and Wales. These show the timber yields of both the remaining trees of the *main crop*, and of the trees removed at various ages and stages as thinnings.

In scientific forestry, yield tables serve much the same purpose as do strength-of-materials data in engineering. They express the capabilities of the forester's working material, the growing tree crop. By their aid, he can forecast future timber yields with considerable accuracy, and plan his work to give the best return.

DIMENSIONS AND QUANTITIES

The figures quoted below are intended merely to give some idea of the range of values usually met with in measuring British trees and plantations. They are neither averages nor extremes, and their purpose is simply to state likely numbers and quantities, and to show how the units mentioned above are applied in practice.

INDIVIDUAL TREES

Ages. Most kinds of trees are big enough for felling for timber at 100 years of age, many before that. Trees will continue to live and grow for several hundred years, if undamaged by accident or disease.

Heights. 100 feet is a good height for a crop of mature trees. Individual trees grow considerably taller, up to 175 feet. Timber heights are several feet less than total heights.

Girths. Measured at mid-point, a girth of 4 feet indicates a large log suitable for use as saw timber. Mid girths over 8 feet are exceptionally large. Quarter-girths are of course one-fourth as large as girths.

Volumes. The volumes of trees, being the products of heights and girths, have a wide range of variation. Many mature trees scale only 20 Hoppus cubic feet, but exceptional trees go up to 200, and even in Britain, trees of over 800 Hoppus cubic feet have occasionally been measured (166, 167).

TREE CROPS

Areas. The surface extent of tree crops is usually measured in acres and decimal fractions; not in roods or poles.

Stems per Acre. Normally about 1,750 trees are planted on each acre of ground, but by the time maturity is reached these will have dwindled, through thinnings, accident, and disease, to about 200 only.

Volumes per Acre. As these are the products of numbers of stems per acre, and volumes of individual trees, which themselves vary widely, a great range of figures occurs. 200 stems per acre, each averaging 30 cubic feet each, have a volume of 6,000 cubic feet per acre, which is a reasonable figure for a good mature crop.

Total Yield per Acre. Besides this final crop, there will have been other timber yields from the trees removed as thinnings, or windblown. A total of 4,000 Hoppus cubic feet per acre is a reasonable figure for these thinning yields, giving a total yield of 10,000 Hoppus feet per acre.

Average Annual Yield per Acre per Annum. Supposing the crop described above had taken 100 years to reach maturity, its yields per acre per annum would be, taking the average of the years:

For the Final Crop only; 60 Hoppus feet per acre per annum.
For the Total Crop; 100 Hoppus feet per acre per annum.

CHAPTER 21

FOREST MANAGEMENT

Forests, by reason of their size and the length of time which their crops take to mature, require a technique of management different from that of most other forms of enterprise. In many kinds of industry, agriculture, and commerce, comparatively short term planning is sufficient, as returns soon come in and conditions may change rapidly. But most tree crops take from sixty to one hundred and fifty years to mature, and so foresters must lay their plans with such periods in view. To do so, they have devised a system of *Working Plans*, to control the treatment of large areas of valuable timber crops over long periods of time. This must be done in such a way that the value and utility of the forest is maintained, whilst at the same time it yields a profit on its management as well as a steady return on the capital invested in the planting and tending of it.

AFFORESTATION PLANS

Plans for the afforestation or reafforestation of a tract of land take the form of a programme of work to be carried out over a period of months or years. They include maps of the land which is to be planted, details of its boundaries and areas, the kinds of trees to be used, their numbers and sizes, and the distances apart and methods of planting to be employed. The number of workers needed for planting and weeding may then be estimated, and also the costs of the work. This enables adequate financial provision to be made in advance for each year's operations, and a nursery programme to be drawn up to supply the necessary trees.

PLANS FOR MAINTAINING AND THINNING PLANTATIONS

These provide for the effective control of each plantation between the initial stage of planting and the final stage of felling. The probable course of events for any given plantation may be mapped-out ahead on lines such as the following:

1st Year.	Planted and Weeded.
2nd Year.	Failures replaced. Weeded.
3rd Year.	Light weeding.
4th Year.	Final weeding.
5th to 10th Years.	No attention needed, except protection.
11th Year.	Cleaning (Removing tree weeds).
13th Year.	Brashing.
15th Year.	1st Thinning. (At this stage selected trees might be high-pruned).
20th Year.	2nd Thinning (5-yearly interval).
25th Year.	3rd Thinning „ „
30th Year.	4th Thinning „ „

40th Year.	5th Thinning (10-yearly interval).
50th Year	6th Thinning ,, ,,
60th Year.	7th Thinning ,, ,,
	(This is the final thinning).
80th Year.	Final Clear Felling of the crop.

Of course, an actual plantation may not conform to the schedule drawn up for it. It may require more or less frequent thinning, and may reach maturity earlier or later. But the progress of a theoretical plantation pursuing a normal course is a useful working guide for the forester.

YIELD TABLES record the normal progress of the commoner forest tree species on various grades or qualities of soil. At a given age, each kind of tree crop should be growing with a certain number of stems per acre, the crop should have reached a certain average height, its individual trees should have attained a certain average girth and timber volume, and consequently the crop as a whole should show a certain average volume of timber. Moreover, in growing to this stage it will have lost a definite number of its trees as thinnings; these also will have had a certain average volume, making a total yield of timber already obtained. This second volume, added to the first, will give the total timber production, felled and standing, up to date.

But it must be realised that yield tables can only form a rough and rather general guide. For example, the numbers of trees carried on each acre at a given age will vary according to the grade of thinning that is adopted. No two crops of trees ever develop in just the same way.

As an example, according to the yield table an acre of Scots pine plantation that has made normal growth on soil of moderate quality will probably carry, when 40 years old, some 1,000 stems. The average height will be 40 feet, and the average timber volume 2 cubic feet per tree, making 2,000 cubic feet *per acre*. Already there should have been removed from it in the course of thinnings some 500 of its smaller trees. These may have averaged 1 cubic foot each, giving a yield to date of 500 cubic feet. The total timber production *to date* is therefore the standing crop plus the thinning yield, i.e. 2,000 plus 500, or 2,500 cubic feet. (Hoppus measure throughout. This is a hypothetical example, though the figures cited are not unreasonable.)

Of course, an actual plantation may contain more stems at that age. Such a wood would probably be taller, but its trees would be of smaller girth and the total timber volume might actually be *less*. Furthermore, there may have been *no* thinnings, and consequently no thinning yield. In such a case, the forester might plan for a more intensive series of thinnings than that required in a plantation whose past history had been more normal.

Conversely, if a wood has been overthinned, and has too few stems per acre for its size and age, the forester may go slow on his thinnings, to retain a usefully dense growing stock of trees.

With the aid of yield tables a technically trained forester can devise plans for thinning and maintaining tree crops of any age, even if they have not previously been worked on any systematic basis. On taking charge of them, he can ascertain their age, volume, and other characteristics, compare them with a normal crop, and forecast their future development. Then he can plan to tend them and use them to the best advantage.

EXPLOITATION PLANS

These provide for the felling of a portion of the forest, when it is nearing maturity, to utilise its produce and provide revenue. They also deal with the profitable disposal of material obtained from thinning immature plantations. It is necessary to decide which areas of woodland are to be felled, and what proportion they ought to bear to the forest as a whole. The woods selected are usually measured and valued, so that the owner has an indication of the probable return. The rate of felling is then decided, and steps taken to dispose of the timber, either standing or as felled logs, to timber merchants. This may be done by private treaty or public auction. Many woodland owners have their own sawmills, and sell or use their trees in the form of sawn timber or finished goods such as gates, etc. On the outbreak of war in 1939, the felling of trees and the use of timber were both strictly regulated, and licences became necessary for handling all but the smallest numbers, sizes, and quantities.

GENERAL WORKING PLANS

These bring together the three processes of Afforestation, Maintenance and Exploitation, so that each proceeds at its due rate. The standard of comparison is the theoretical " Normal Forest." The word *normal* is here used in a special sense, to represent the forester's ideal, rarely found in fact. A normal Forest consists of many tree crops (or individual trees) so distributed by ages and sizes that there are always ample mature trees to fell, and enough immature trees growing up to replace them. Such a forest can be exploited for ever, without its supplies of timber diminishing or failing for even one season.

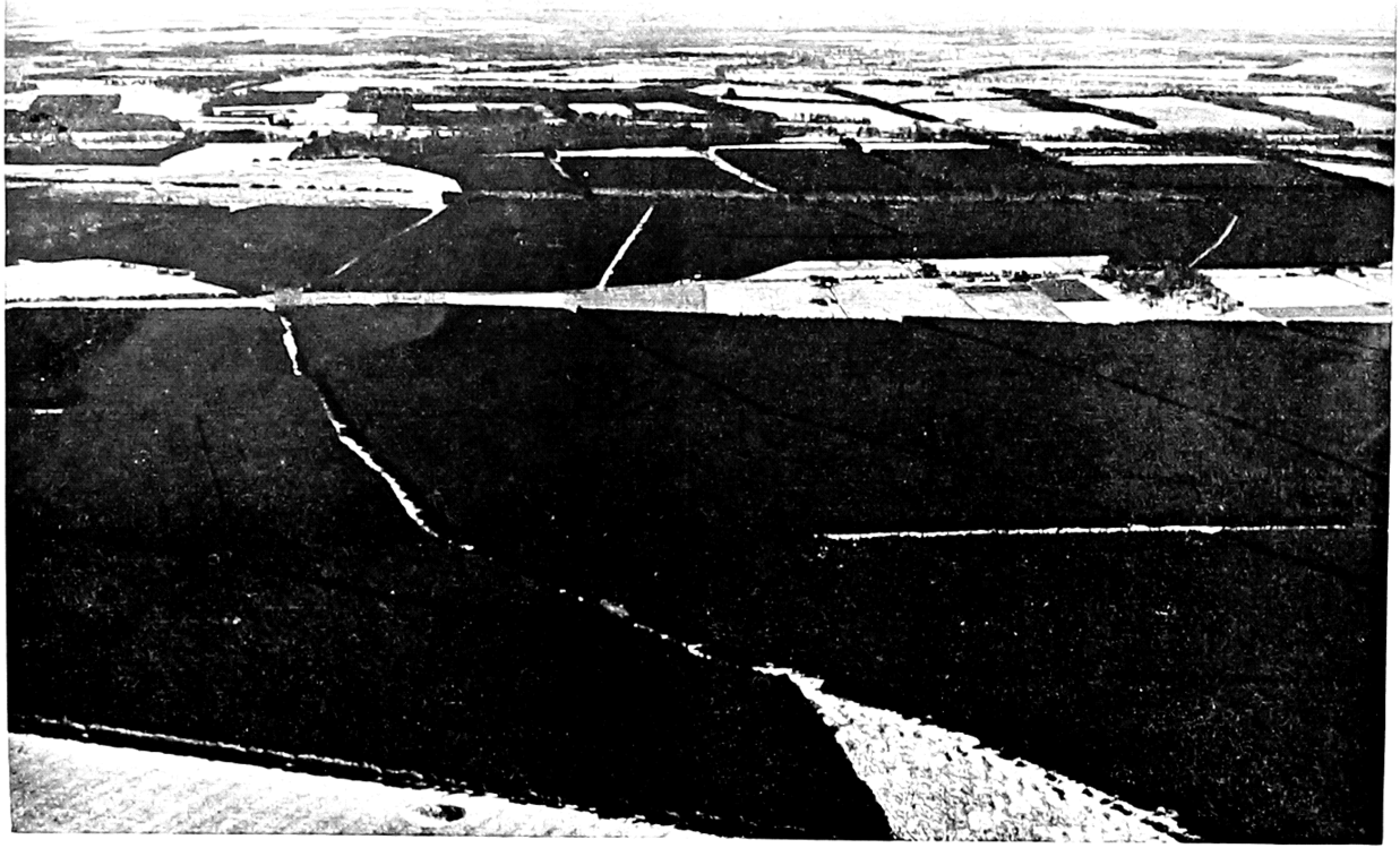
To take a simple case, if Scots pine is being grown to an age or rotation of 100 years in a forest that covers 1,030 acres, then every year there should be 10 acres of trees maturing and becoming fit to fell. After felling, this will free an equal area of 10 acres for re-planting, but it would be necessary to let the actual ground lie fallow for at least 2 years to avoid damage from Pine Weevil and the difficulty of planting in raw conifer leaf mould. So every year one ten-acre plot would be felled, another re-planted, and two others allowed to lie fallow. For this process to be kept up indefinitely, it would be necessary for the remaining 990 acres of the forest to consist of 99 plots of 10 acres each, aged from one year old to ninety-nine years old. So every year a fresh crop would ripen or mature and be felled. The annual yield of timber, from final fellings and thinnings, would always be more or less the same.

The *General Working Plan* for such a supremely simple forest would simply outline the annual felling and tending operations, which would be the same year after year. There would always be 10 acres to fell, 10 to replant, so many units of 10 acres each to be weeded and thinned, each at their appropriate ages; the work could go on for ever on the same plan, with the forest continually yielding its due quota of produce.

Forests approaching this state of *normality* exist on the continent of Europe, but are rare or non-existent in Britain. Nevertheless the ideal is constantly aimed at, for sustained annual yields are a great asset to any forest estate. They mean that money is continually available for the continuing expenses of management and re-planting, whilst after these costs have been covered there should also be a steady surplus of profit for the woodland owner.

168 GROWING BEECH BENEATH BIRCH AT BURITON FOREST, HAMPSHIRE

169 A FORESTRY COMMISSION SAMPLE PLOT OF NORWAY SPRUCE, HEAVILY THINNED; EVERY TREE IS NUMBERED AND MEASURED



170 AN AERIAL VIEW OF THETFORD CHASE, NORFOLK, SHOWING HOW A GREAT FOREST IS DIVIDED INTO COMPARTMENTS BY RIDES PLANNED FOR ACCESS AND FIRE PROTECTION

MAKING A WORKING PLAN

Forests resembling the theoretical " normal " are so rare that the forester who has to prepare the average General Working Plan is faced with a task of great perplexity which may well tax his professional skill to the utmost. The area to be planned may carry a tree crop of many kinds of trees and an uneven distribution of ages and areas of land under trees of each age; in short a hotchpotch which he must bring to some semblance of ordered arrangement. He prepares his plan in three stages.

First, it is necessary to know as much as possible about the forest, its extent, boundaries, situation, soil, climate, suitability for the growth of various kinds of trees, native plants, animals, and local demands and uses for timber; to this must be added a detailed knowledge of the existing tree crops. Secondly, the planner must know the objects which the woodland owner wishes to achieve. Thirdly, he must devise a plan to mould the existing forest into the pattern of growth which will produce the desired result.

Large-scale maps form the basis of every Working Plan. Topographical maps such as the 25-inches-to-the-mile of the Ordnance Survey can be coloured up to show the actual distribution of existing plantations of different kinds and ages, as found by actual inspection on the ground. Such amended maps are termed *Stock Maps*. From them, the areas of each class of crop can be computed. They also provide a groundwork for dividing up the whole forest into units for management purposes, called *Compartments*, usually from 20 to 30 acres in extent.

Besides measuring areas, it is generally essential to estimate the volumes of selected tree crops or plantations, on the lines described in the preceding chapter, and to ascertain all that is known about the past history of each block of woodland. This results in the accumulation of a mass of detailed information that can only be handled easily when expressed in tabular form. It is therefore entered on statements known as *compartment forms*, since the unit of entry is the compartment.

Having acquired this detailed and specialised knowledge of the forest area, the planner must then consider the *Objects of Management* desired by its owners. As a rule, the owner or owners will require their forest property to be maintained in good order as a long-term investment, giving a steady annual yield of timber and monetary returns. Subsidiary objects may include the provision of cover for game, preservation of local scenery, protection of water catchment areas, or the like. The *period* of the plan, usually for ten years or some similar length of time, must also be decided.

The third stage, the real planning, consists in arranging an ordered sequence of operations over the area as a whole, in such a way that the growth of the various plantations conforms with the objects desired. The woods that are to be felled must be specified, and the order of felling decided, together with the rate at which it is to proceed. A programme of re-planting, or new planting, has to be drawn up, stating the pieces of land to be dealt with each year, the kinds of trees to be planted in each case, and the methods to be followed. A similar programme is required for the tending and thinning of young tree crops in the intermediate stages. These three aspects of forest management must be so governed that they work into a coherent scheme, each keeping pace with the others.

PLANNING BY AREAS. This is the simplest method of guiding the progress of the woodlands. The planner prescribes a certain acreage, or area of land, to be felled each year, another acreage for re-planting, and still other areas for annual thinning, weeding, and similar maintenance work. He indicates, both in his written plan and on the stock maps, where these actual areas lie, together with the sequence of operations. Very probably, he will draw special maps each showing the cycle of fellings, plantings, or upkeep work which he recommends. All this must be arranged with due regard to the existing plantations, and their ages and conditions.

Obviously, the area to be felled and re-planted each year should bear a certain relationship to the size of the forest as a whole. In a *normal* forest, this relationship can be determined by a simple formula, as follows:

$$\text{Felling Area} = \frac{\text{Total Area}}{\text{Rotation}}$$

For example, in a forest of 1,000 acres, where the crop is to be grown on a rotation of 100 years, the area to be felled annually will be:

$$\frac{1{,}000}{100} = 10 \text{ acres}$$

(In actual practice this formula may need modification. In the example of a *normal* forest quoted earlier on, an area of 1,030 acres was needed in order to allow of the felling of 10 acres each year on a 100-year rotation).

As a rule, the forest to be managed under the Working Plan will be far from *normal* at the outset, and it may be desirable to fell a larger or a smaller proportion of its theoretical quota each year, or even to suspend fellings entirely.

PLANNING BY VOLUMES. A more advanced method governs the amount of felling that can be permitted, by reference to the volume of timber which grows in the forest each year. If the growing stock of a forest is *normal,* then the annual increment in volume can be cut each year without damaging its prospects of growth, provided the cutting is done in the right plantations. In other words, the trees are cut down just as fast as they grow, but no faster.

Planning by volumes must be based on a careful estimate of the existing volume of timber actually standing in the forest, together with its annual increase. Provided the amount felled each year does not exceed that increase, fellings can go on indefinitely without diminishing the total volume of the forest crop. A re-measurement after a few years will show whether or not the cutting is too drastic; if cutting is proceeding too fast, the rate can then be modified.

For example, a forester may measure a forest of 1,000 acres, and find that the volume of timber growing on it is 2,000,000 (Two million) Hoppus cubic feet. Then he may calculate that the annual increase in this total volume is equal to 5% of it, or 100,000 cubic feet. So he may fell at this rate for 10 years. If his calculations were correct, the forest will still contain 2,000,000 cubic feet, although he will have cut out 1,000,000 cubic feet over the ten-year period. All the loss will have been made good by natural increase, for a well-managed forest replaces the losses due to felling.

But perhaps his figures were too optimistic, and in fact the annual increase was only 4%, or 80,000 cubic feet per year. Then it will only have grown 800,000 cubic feet whilst he cut out 1,000,000. Therefore it will be 200,000 cubic feet smaller at the next measurement, and only scale 1,800,000 cubic feet. This is a serious matter, because it means that he is cutting into his *capital* of growing timber, besides taking the *interest* which comprises its annual growth. But the fault can be remedied by cutting more slowly over the next ten-year period.

This leads to a simple rule governing the planning of forests according to their timber volumes. If the amount cut exceeds the increase in growth, the volume of the remaining tree crops will *diminish;* if it falls short of that increase then the volume of the remaining tree crops will *increase.*

Such volumetric planning is based on the consideration of *normal* forests, but is capable of extension to other types. It has a great advantage over area planning in the management of Selection Forests (see Chapter 13), in which trees of all ages and sizes grow together in an intimate mixture; in such forests areas carrying trees all of the same age cannot be defined, but volumes can still be measured and the increment in volume estimated.

Interesting formulae have been deduced to aid the forester in calculating just what volume he may safely cut from different kinds of forests, whether *normal* or otherwise.

COMBINING AREA PLANNING WITH VOLUME PLANNING. The two methods of planning forests, though separate in theory, are usually combined in practice. When once the possible volume to be cut has been worked out for each year's felling, it has to be located on some definite area of ground. Conversely, each area is expected to yield a certain volume of timber when it is felled or thinned. The sample plan which follows shows how this may be arranged.

A SAMPLE WORKING PLAN

Forest planning, like other forms of abstract organization, is difficult to follow unless there is some concrete example available for study. The sample plan given below is, of course, imaginary and very much abridged, but it may help to show how the principles of Working Plans are applied to the control of actual forests.

DESCRIPTION OF THE FOREST. The forest to be managed on an ordered Working Plan is known as the Far Valley Woods, and is situated in north-east England. It covers 800 acres of poor soil, overlying the Millstone Grit rocks of the Carboniferous series, at an elevation of 700 feet above sea level. The rainfall is 45 inches per year, but the woods lie low down in the valley of the Far river, and so are not unduly exposed to the winds.

The whole forest has been bought by the Slowburn Coal Board to ensure a steady supply of pit props and mining timber to their pits. The owners aim to secure a steady flow of material, which will represent a steady return on the capital which they have invested by purchasing the woods. They require their forestry operations to be planned for the next ten years on those lines.

THE GROWING STOCK. Surveys and Stock Maps show that there are 200 acres of oak woods, 140 years old, 60 feet high, carrying 2,000 cubic feet per acre, Hoppus measure. Now growing extremely slowly, at the rate of only 20 cubic feet per acre per annum, and unlikely to improve on this poor soil.

400 acres carry conifers aged 40 years, the species being Scots pine, European larch, and Norway spruce. These have an average height of 60 feet, and a volume of 2,500 cubic feet per acre. They are growing rapidly, and increasing in timber volume at the rate of 80 cubic feet per acre per annum.

A further 200 acres carry much younger plantations of Scots pine, aged from 1 to 10 years old, in blocks of 20 acres of each age.

COMPARTMENTS. For purposes of management, the whole forest is divided into 40 compartments of 20 acres each, or thereabouts. Thus there are 10 compartments in the 200 acres of old oak, 20 in the 400 acres of middle-aged conifers, and 10 in the 200 acres of young Scots pine.

1. FELLING PLANS. The oak is clearly due for felling. Each year for the next 10 years, one compartment of 20 acres will be cut. This will yield at least 40,000 cubic feet of timber per annum, all of which can be used by the coal company in their mines, as sleepers, beams, and so forth.

2. THINNING PLANS. All the middle-aged conifer plantations require a thinning during the next 10 years. There are 20 compartments of them, so 2 compartments must be thinned each year. This involves thinning 40 acres per annum; the thinning yield is estimated at an average figure of 500 cubic feet per acre, being one-fifth of the present volume of the standing trees; so the annual yield will average 20,000 cubic feet of small coniferous timber, all suitable for use as pit-props in the mines.

3. PLANS FOR MAINTENANCE. The young Scots pine plantations require in some cases weeding, in other cases cleaning. As they grow older, each compartment in turn must be brashed. The year in which each compartment is to receive each kind of treatment is laid down in the plan. Arrangements are also prescribed for protecting the young trees from fire, rabbits, and deer.

4. REAFFORESTATION PLANS. Every year, as the oak is felled under (1) above, one compartment of 20 acres will become available for reafforestation. As pitwood is required, it will be inadvisable to re-plant with slow-growing oak. Scots pine would succeed, but its growth would be only moderate, though faster than the oak. The biggest volume of pitwood would be obtained in the shortest time by planting the newer conifers, in particular Sitka spruce, Douglas fir, and Corsican pine. One compartment will therefore be planted as a pure block of one of these species each year, the actual one chosen being varied according to the local conditions; if for any reason enough stocks for planting the area cannot be obtained from the nurseries, then Scots pine or Norway spruce may be used as substitutes.

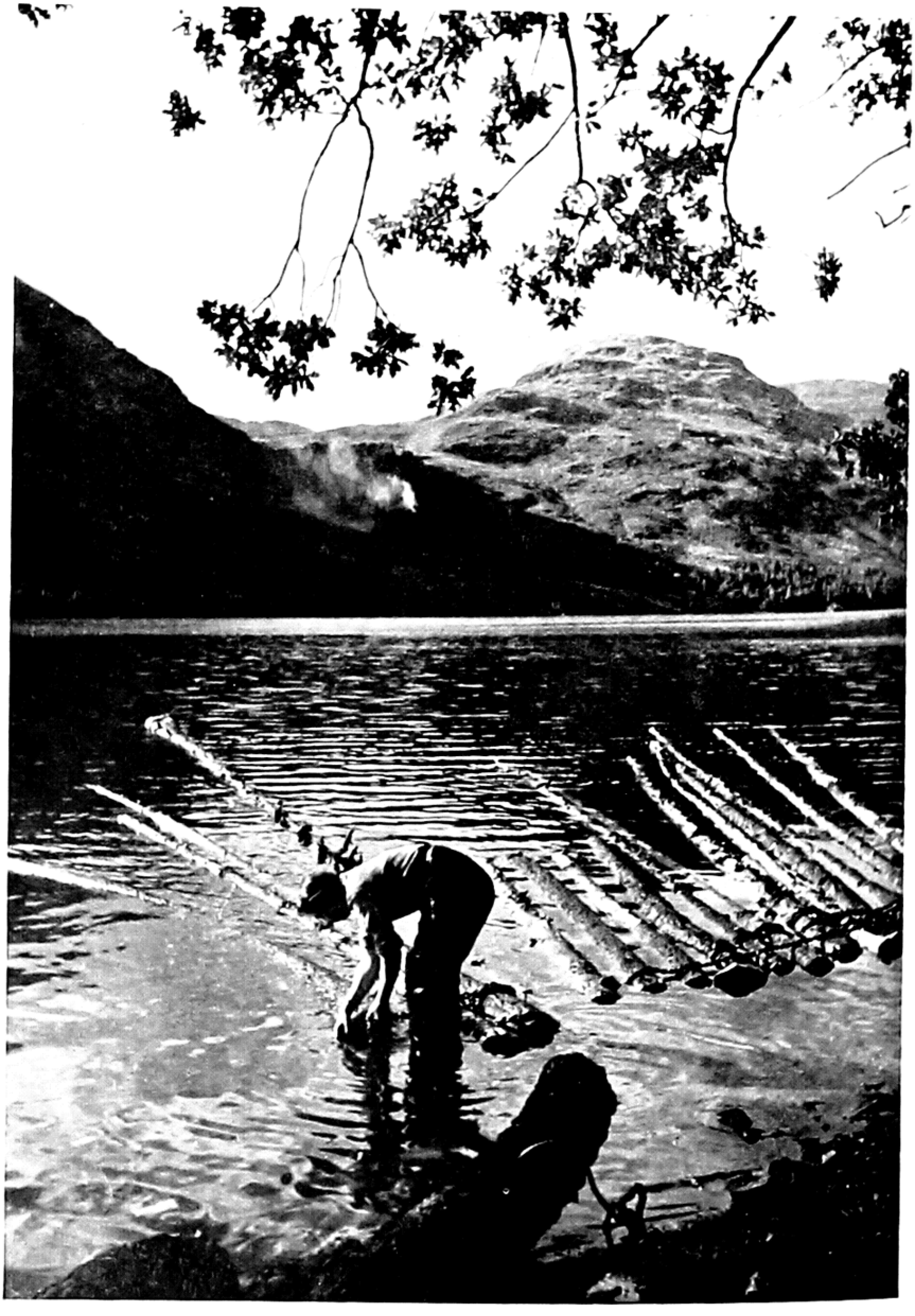
With this plan before him, the forester in charge can see at a glance how much timber will be cut each year. He can arrange to employ tree-fellers, hauliers, and saw-millers, calculate his expenses and estimate his net return from the sale of produce (in this case credited through the mine accounts).

On the other side of the account, he can calculate how many workers are needed for weeding, brashing, fencing, and re-planting. Also how many trees he will have to raise or purchase each year to keep up his planting programme.

He can then forecast whether each year's operations are likely to show a profit or a loss. In all probability, the annual receipts from 40,000 cubic feet of oak, and 20,000 cubic feet of coniferous pit-props, will far exceed the yearly costs of re-planting 20 acres with conifers and maintaining the area as a whole, even when overheads and management charges are considered. This difference will accrue to the owners as interest on their investment in the forest, due allowances being made for taxation.

The test of this plan is to see whether it will meet the objects desired by the owners. After 10 years working, they will have disposed of 200 acres of oak, which was not growing well, and have acquired instead 200 acres of young

171 THE GREAT WOODS OF ATHOLL, ABOVE DUNKELD IN THE TAY VALLEY, PERTHSHIRE



172 RAFTING TIMBER ACROSS LOCH VOIL, PERTHSHIRE

conifers, growing rapidly towards pitwood size. The rest of the original crop will be still standing and increasing in volume and value. Each year will have brought in its supply of timber and pitwood, and the value of this to their mines should have shown a working profit, after meeting all expenses, that will represent interest on their capital.

So far so good, but is the forest being felled too fast, and what can be cut down when the oak is all finished? There are 40 compartments, and as one is felled every year, no trees can grow to a greater age than 40 years after the plan has once got into its stride. This is not a great age, but is quite satisfactory for pitwood, which is the main requirement. After the oak is all gone, there are 400 acres of conifers to be cut for the next 20 years, to be followed by 200 acres of purchased young Scots pine, and thereafter by the conifers replanted systematically each year by the company. By degrees, this forest will become a *normal* one, and it can be managed on the same profitable plan indefinitely, forming a capital investment that may yield dividends for hundreds of years, if not for ever.

CHAPTER 22

FOREST ECONOMICS

The economic aspects of forestry form a very wide field of study, extending to such questions as credit facilities, wage rates, prices for timber and their relation to those of other commodities, taxation, land dues, import duties, rent of land, and even such abstruse matters as the comparative values of money at the time of planting and at the time of felling the tree crop. Whether it will pay to pursue or extend the practise of forestry under any particular set of circumstances is a matter for the expert, with all the facts of the case at hand, to decide. Current costs and prices cannot usefully be quoted, because they may vary so rapidly, and the same is true of regulations governing overhead financial charges, allowances, or grants.

Nevertheless there are certain continuing relationships between the rate of growth of forests and the money value of their crops, which form the framework of the forest economist's calculations. These underlying and fundamental factors continue unchanged despite variations in actual values of timber or the cost of producing it. They are of interest because they apply particularly to tree crops, mainly on account of the long periods of time which these take to mature.

Three aspects only of this involved study will be dealt with here. The first is the financial yield from the growing of a single even-aged plantation, the second the valuation of timber and tree crops, and the third the sustained money yield from a *normal* forest. The sums of money mentioned are used in every case as examples only, and do not necessarily represent current costs or prices.

THE RETURN FROM A SINGLE PLANTATION

The economist looks upon the financial side of forestry as a long term investment. The time interval, between planting the trees and selling the timber obtained from felling them, is so long that the financial return is not measured as profit but as *interest on capital.* This interest has to be spread over the whole period of years during which the crop is growing, and in order to pay a reasonable rate of interest the crop must steadily increase in value.

Young plantations cost comparatively little to establish. For several years they continue to be too small for use as timber or even as poles, giving no return on the capital investment. Then, as thinnings are made, small cash returns come in, but the main bulk of the capital remains locked up in the growing stock of trees. Finally, when the timber crop is mature, it is usually cut down in one clean sweep, and there is a sudden realisation of the whole investment, often at a figure many times its original cost. But many years, perhaps a hundred or more, will have elapsed since the first investment in the tree crop was made.

Tree Crops and Compound Interest. Few other forms of investment have the same character of a large but long-delayed return. The nearest parallel is investment at compound interest. This is therefore widely used as a basis of comparison for the profitability or otherwise of tree crops.

As is well known, the value of a sum invested at compound interest increases with growing rapidity as the years go by. This is best shown by an example. Suppose £10 is invested at 3% compound interest. The value of this capital sum, plus interest, will increase at the following rate:

Time	*Value to nearest £*	*Increase in Value over 10 years.*
Start.	£10	——
After 10 years	£13	£3
„ 20 „	£18	£5
„ 30 „	£24	£6
„ 40 „	£33	£9
„ 50 „	£44	£11
„ 60 „	£59	£15
„ 70 „	£79	£20
„ 80 „	£106	£27
„ 90 „	£143	£37
„ 100 „	£192	£49
„ 110 „	£258	£66
„ 120 „	£347	£89
„ 130 „	£466	£119
„ 140 „	£627	£161
„ 150 „	£843	£216

To yield a comparable rate of interest, a tree crop must increase in value at a similar rate, as its age advances. This it can usually do provided the rotation, or interval between planting and felling, is not too long. The table given above shows that every £10 invested in a tree crop, as for example in planting an acre of forest land, must give rise to an increase in the value of the crop of £20 between the ages of 60 and 70 years, to show 3% compound interest. But between the ages of 140 and 150 the comparable increase would have to be £216, over 10 times as much!

Fortunately for the forester, few of his tree crops have to grow to an age over 100 years before harvesting, oak being the only common exception. So the forest economist usually finds that a rate of interest reasonable for such a long-term investment, i.e. from 3% to 5%, is yielded by forest crops, provided:

(a) That the rotation is reasonably short.
(b) That the first costs of planting, etc., are low.
(c) That the final timber crop is valued at a fair figure.

The formulae he uses resemble those of the actuary. They are complicated by considerations of maintenance costs, such as the rent of the land on which the crop grows, and by intermediate cash returns from thinnings, etc. They involve interesting exercises in mathematics, but cannot be explained briefly in simple language.

These formulae give due weight to four main factors—interest rates, first costs, final values, and the length of the rotation. Each depends on the other three. If two are fixed, and a third varies, the fourth will vary to the same relative degree. For example, given a certain *fixed* first cost, from which a *fixed* rate of interest is desired, the rotation may be varied provided the final value also varies in the right proportion.

Thus, where a crop has cost £10 per acre to plant, and a yield of 3% compound interest is required, it may be felled at *any* age provided its value is equal to the sums shown in the 3% table above. If the forester decides to fell it when its market value is *greater* than that shown, he will obtain a *higher* yield of interest. For the value of a crop often exceeds the comparable return at compound interest for a period of years, though ultimately the compound interest amount overtakes it. Therefore these calculations may show the forester when it will pay him best, on theoretical grounds, to fell his crops.

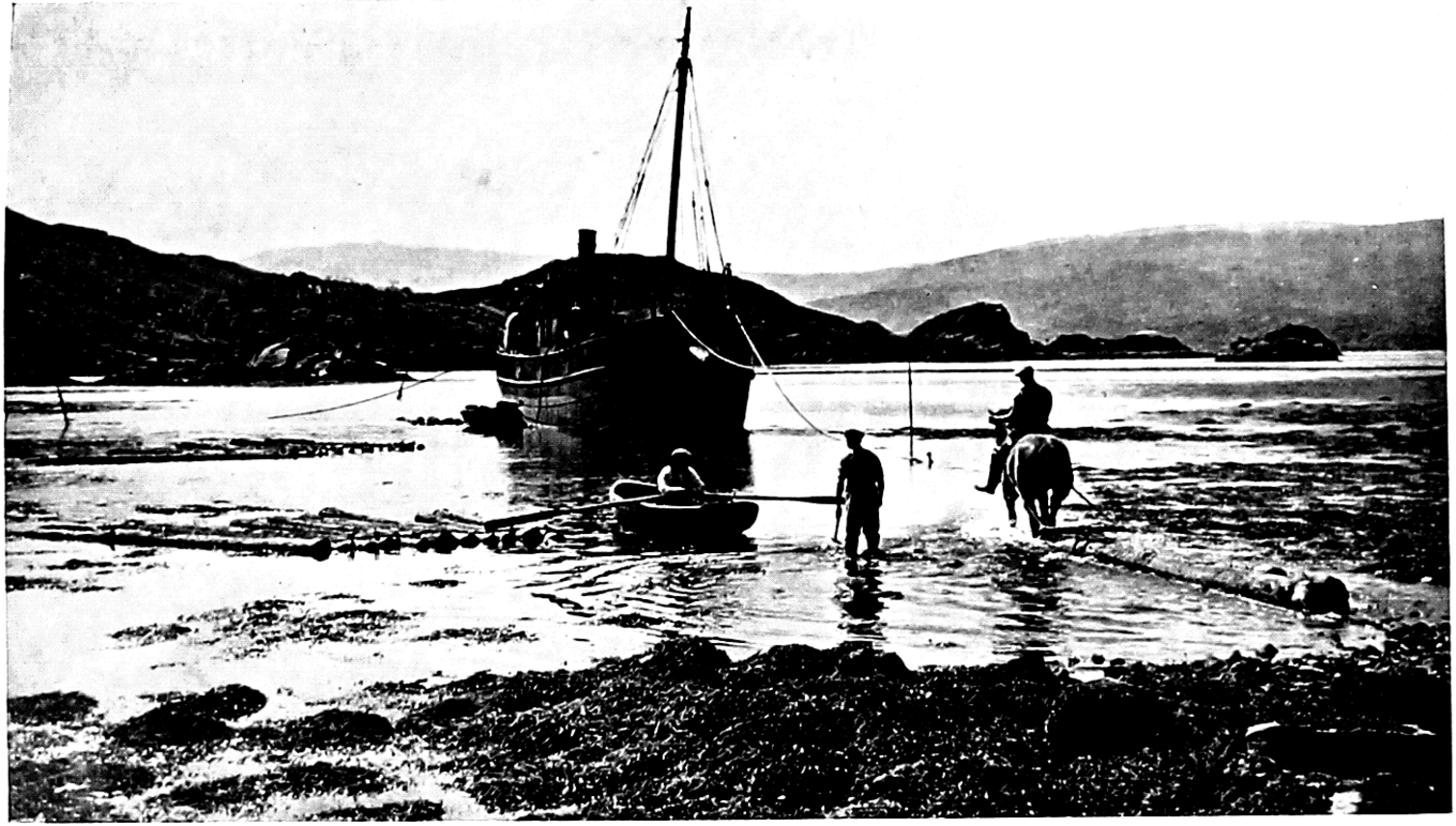
TIMBER VALUES

When considering Forest Management in the previous chapter, it was seen that the *volumes* of timber produced in any given time, by the tree species commonly grown, under varying soil conditions, can be forecast with reasonable accuracy by means of Yield Tables. Volumes, however, are widely different from *values*, so much so that the volumetric yield acts only as a pointer to the financial yield. Actual cash returns depend not only on the volume of timber produced within a given period of time, but also upon the forester's skill in marketing his produce when once it is grown, and on his ability to grow material of high quality and large diameter, adapted to most profitable uses.

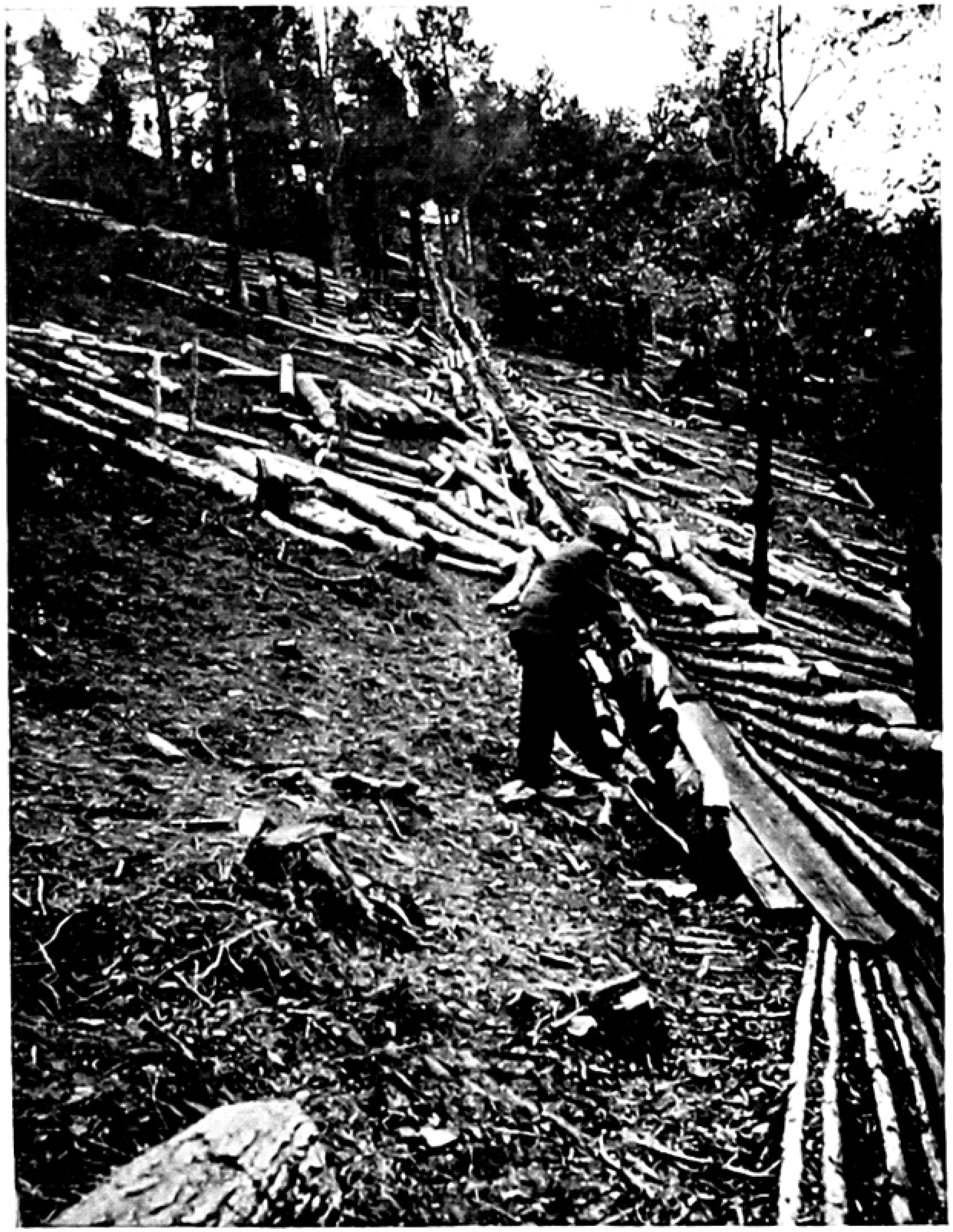
The value of timber is based on the uses to which it can be put when it has left the forest. Therefore those kinds and qualities which are suitable for special uses tend to bring higher returns, per unit of volume, than the general run of general purpose material. The timber merchant who buys the standing trees has to consider the margin of profit that will be left to him after he has paid the costs of felling the trees, hauling out the logs, conveying them to his mill, and cutting them up into the form in which he finally sells them, as planks, boards, etc., or finished goods. Therefore the value of any particular tree as it grows in the wood, will depend, amongst *other factors*, on:

1. Its volume of useful timber.
2. Its species.
3. Felling costs, bark allowances, and sundry expenses.
4. The cost of hauling it out when felled.
5. The distance of the wood from the nearest sawmill or railway station, or ultimate destination of the material.
6. Its general quality, straightness, and freedom from defects.
7. Its suitability or otherwise for specialised work.
8. Its *diameter*.

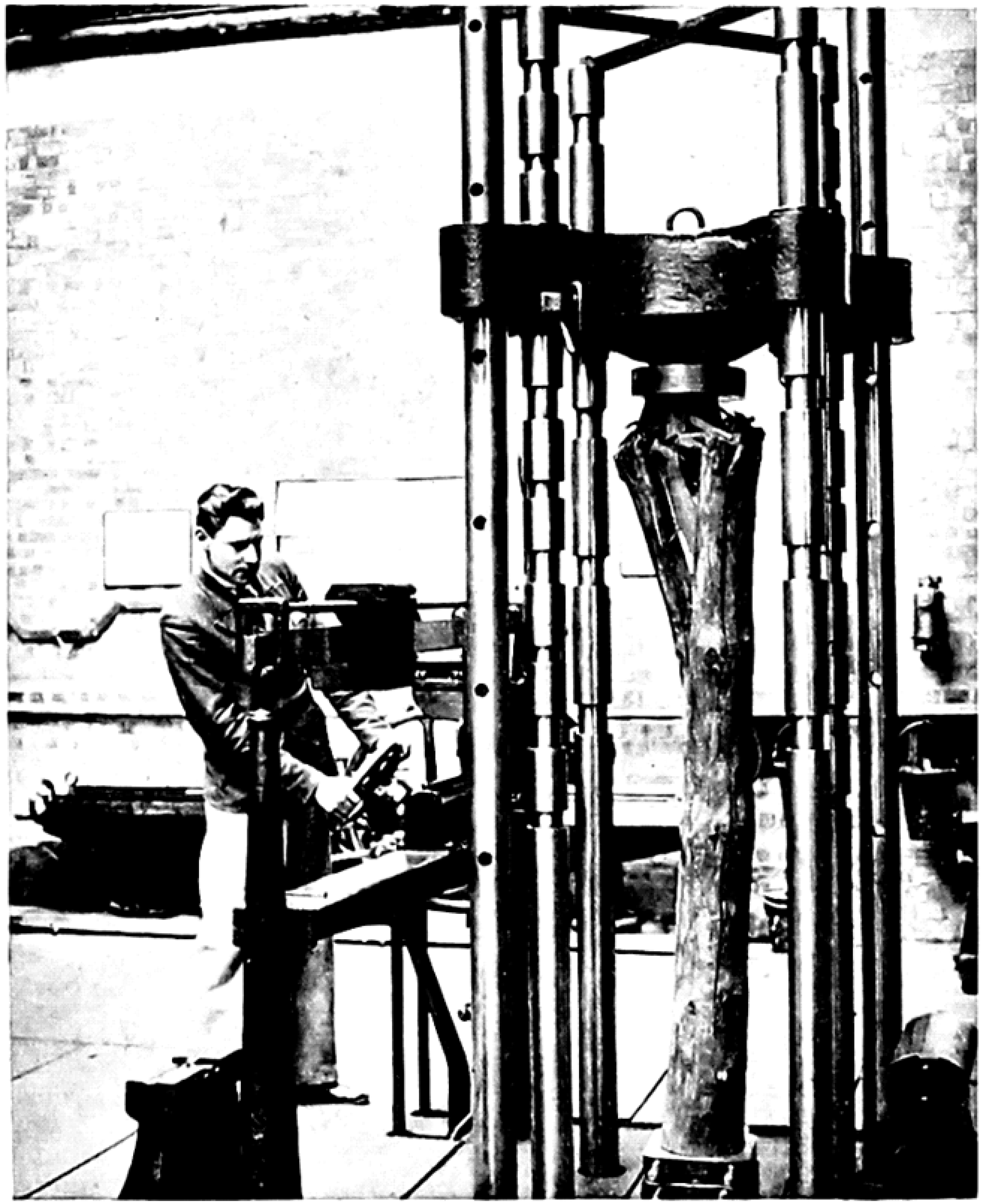
The first seven of these points may be readily understood without further explanation, but the eighth is peculiar to timber as a commodity. When discussing utilisation of timber in Chapter 18 it was seen that sawmillers prefer large logs, because they cost less (volume for volume) to handle, give less waste, and are adaptable to a wider range of uses than smaller ones. Also they contain a higher proportion of heartwood, a feature of great value in some species, such as oak. This preference finds expression in actual prices,



173 RAFTING TIMBER TO A COASTING STEAMER IN AN ARGYLLSHIRE SEA LOCH



174 A TIMBER SLIDE, CARRYING POLES DOWNHILL BY GRAVITY



175 TESTING PIT PROPS TO DESTRUCTION AT THE FOREST PRODUCTS RESEARCH LABORATORY, PRINCES RISBOROUGH

TECHNICAL ADVANCES

and larger logs are worth more *per cubic foot* Hoppus measure (or other unit of volume) than smaller ones.

For example, in 1942 the controlled prices for oak of various sizes and qualities, measured by the Hoppus system and sold when standing in the wood, were:

Selected trees, over 18 inches quarter girth:		3/6 per cubic ft.
ditto	14 to 18 ,, ,, ,, :	2/6 ,, ,, ,,
ditto	12 to 13¾ ,, ,, ,, :	2/- ,, ,, ,,
Other well-grown trees:		1/6 ,, ,, ,,
Inferior in size and quality		9d. ,, ,, ,,

The size classes defined in this manner are known as *quarter-girth categories*, and similar ranges are commonly employed for round timber of all species. Hence it is not enough to know the mere *volume* of timber available. If a large proportion of it comes into the larger quarter-girth categories the total value will be much higher than if the bulk of it consists of small-sized and inferior trees.

Until the trees are felled it is difficult to ascertain just what proportion of their volume will lie in the higher-priced quarter-girth categories. Therefore many contracts for the sale of standing timber specify a *scale* of prices, leaving the actual amounts to be determined when the trees have been felled. The buyer may do the actual felling, but when the trees are down both parties check the measurement, and calculate the value on the pre-determined scale.

The " other factors " mentioned above as governing timber values, are the general level of current prices, the relation of demand to supply, the quantities offered, the contract terms, and similar considerations which are common to all commercial transactions. In war-time, timber prices were subjected to control, and a definite schedule was laid down to show the permitted price of each quarter-girth category of each species, together with rules for determining the net measurements, as for example by deducting bark allowances. Such schedules specify also the point at which the transfer of ownership takes place, which has a marked bearing on the price per cubic foot.

For example, in 1942 the controlled price for coniferous timber (other than larch) in the form of logs of 12 inches quarter-girth and over, was 1/- per cubic foot Hoppus measure in the case of standing trees. If the trees were sold after felling, the price rose to 1/1½ per cubic foot to cover felling costs. If the logs were sold after being conveyed to the nearest station, the figure was increased to 1/10½ to allow for haulage charges. Bark allowances were fixed at 10% in Scotland, and 7½% in England and Wales. The prices of sawn timber, planks, boards, quartering, etc., were likewise controlled and regulated.

VALUING PLANTATIONS

The assessment of the value of a stand of timber is a matter for the expert, but the methods he uses may be simply outlined. First of all he must measure the timber content of the growing crop, assuming it is old enough to contain merchantable timber, by methods such as those described in Chapter 20. He has to tabulate the details of timber volumes by species, for values of timber vary widely from one kind of tree to another.

Next he must estimate the quality of each kind, and consider what proportion of their timber will be of large enough diameter to go into the highlypriced larger quarter-girth categories. Then he will consider local features, such as the ease or otherwise of timber extraction and the distance to sawmills or other centres of consumption.

Finally he will consider current market prices, and so be enabled to set a price upon timber of each grade or kind, as it stands in the wood. Further calculations will give the value of the whole plantation, or of a whole forest.

If any plantations are too young for sale as timber, the valuer will probably consider what they are likely to be worth in so many years time, and assess them at some proportion of that figure. The cost of planting them may be known, but the chances are that they will be worth more than, or less than, that figure.

The land itself is usually valued quite separately from the tree crops growing upon it, as its value per acre is governed by factors distinct from those affecting the value of the timber which it bears. Forest land, without crops, is seldom of high value, owing to its unsuitability for general farming or other uses; £2 or £3 per acre is quite a usual figure.

THE ECONOMICS OF A NORMAL FOREST

In a *normal* forest, so planned and managed that it will yield timber for ever without diminishing in value, the financial result is, in theory at least, fairly easy to determine. Every year there will be an income from the sale of timber, and an expenditure on upkeep. The excess of income that will usually result will be the working profit, and this may be expressed as *simple* interest on the capital value of the whole forest. Such calculations are in fact made for certain forests in Europe and India, many of which yield steady annual returns to their owners.

In order to obtain a true result, the forest must be managed in a truly *normal* manner. Any excessive felling would cut into the substance of the growing stock, and though it might show a high percentage return on paper, this would represent in part a diminution of the capital investment. On the other hand, too slow a rate of felling would result in the growing stock being built up above its *normal* value; although it would show a diminished money yield, it would lead to the accumulation of further capital in the form of standing timber, and this could be realised at some later date.

This does not necessarily imply that the yield from any given *normal* forest is a fixed one. Economies might be made in management, or better prices obtained for timber, which would lead to higher returns without upsetting the *normal* lines of procedure which aim at continuing the profitable growth of timber in perpetuity.

This leads on to the wider question of whether forests can profitably produce all that is demanded of them. Is the cost of growing the timber ever likely to out-run its commercial value when it is grown and ready for marketing? This issue is apt to be obscured in Britain by the fact that so much of the timber used here is imported, and so the prices may vary more according to the state of foreign trade and exchange rates than according to the stricter rules of costs of production in relation to demand. But the very fact that countries such as Sweden and Finland, which manage their vast forests on a *normal* basis of continued and sustained annual yields, find it profitable to grow timber for export, indicates that well-managed forestry can be a commercial success.

Tree crops grow on land of low value for any other purpose, the substance of their timber is built up from air and water for which no charge is made, and the energy which sustains the process of their growth is given free by the sun. The mineral food which they take from the soil is returned in a large part by falling leaves and discarded branches, so that they increase rather than diminish the fertility of the soil that supports them. Thus they may be grown repeatedly on the same site without the aid of fertilisers. The insects which attack them are usually controlled free of charge by birds or other insects, and if the young seedling trees are protected from damage the forest may be induced to renew itself after well-planned fellings, without the toil of man's hands in replanting. No form of land-use produces so much with so little direct labour. In established woodlands the greater part of the work often consists in converting and using the wood when once it is grown.

There are some who fear that the cost of growing timber may become too high in relation to substitute materials. But forestry too has its technicians, who are constantly seeking out ways and means of cheapening production and cutting out waste. New kinds of trees, new methods, new machinery, have the same effect in forestry as do new processes in competitive industries. Scientists are continually devising new means of lessening losses through forest fires or tree diseases. All this makes for increased production at less cost, and a more effective utilisation of the land under forest crops.

Forests, therefore, may form an economic asset of the highest value, alike in times of war and peace. The skill of the forester, who preserves or increases their productivity, ensures a constant or even a growing supply of the timber which is the raw material of many industries and a source of wealth to the community as a whole. There are other, less tangible, advantages which arise from preserving the woodlands of the country, and some of these are touched on in the following chapter.

CHAPTER 23

THE FOREST IN LITERATURE AND THE ARTS

In the days when Britain was a forested land, the wildwood gained a place in English literature that it has never since entirely lost. The early songs and dramas of woodland outlaws take us back to a romantic age that has faded before the advancing urbanization of our life and work. No country in Europe has so little woodland, such widespread towns. Yet every boy's hero is Robin Hood of Sherwood, and every playgoer has heard of Rosalind in her Forest of Arden.

Our woodland, moreover, has afforded material for the graphic and constructive arts. Constable brought our trees to sunlit and windswept life on canvas. The landscapists of the eighteenth century used trees themselves as a medium of expression, planting them to enhance the beauty of parkland and mansion. Shipwrights, carpenters and woodcarvers found in English oak a medium worthy of their craft. Modern sportsmen ply oars of ash or bats of willow, which, like the yew bows of their forefathers, are skilfully wrought from the native timbers of the English woodland.

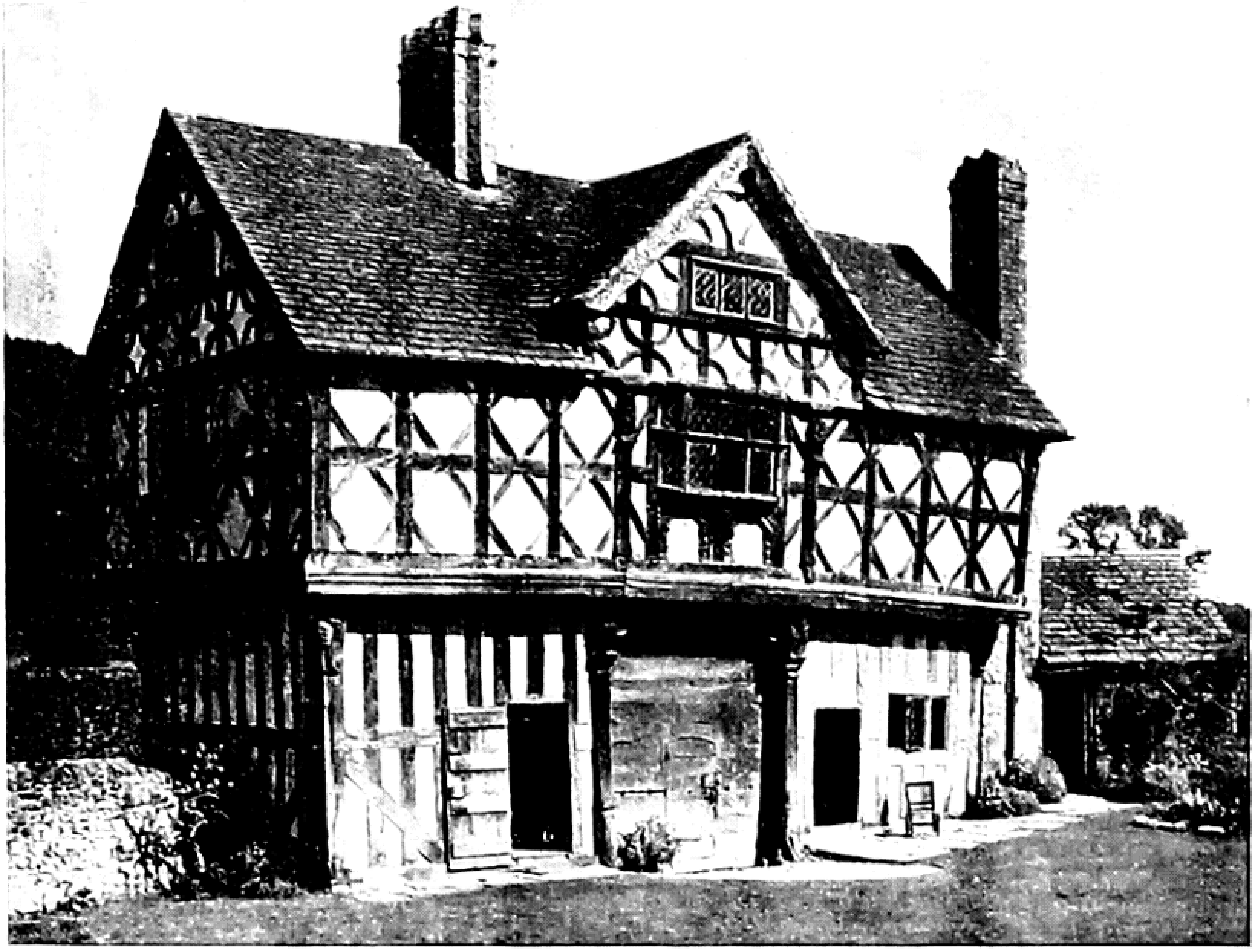
The effect of this forest heritage upon each facet of British culture has varied greatly from century to century. Once oak moulded the form of our domestic architecture; now its more important function lies in the construction of furniture. Our poets no longer find our woods teeming with merry men, whose exploits form the themes of stirring ballads. Instead they walk soberly beneath " dreamy, gloomy, friendly trees," and record their greenness in lyrics. The influence of the forest background changes, but endures. Its effect on each form of art may be traced through the centuries.

ENGLISH BALLADS

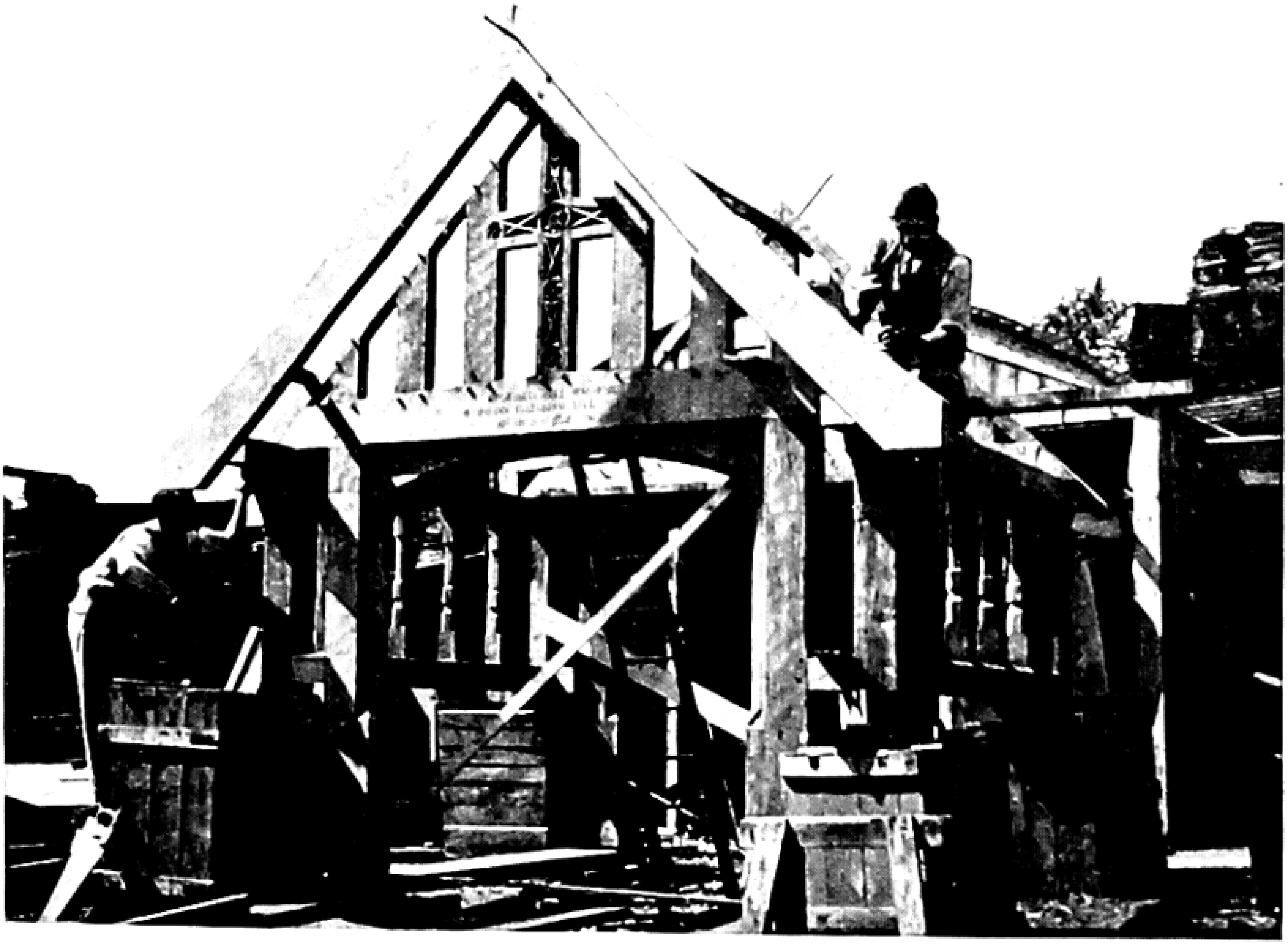
The earliest literature in the modern English speech took the form of ballads, which arose as songs or poems passed on by word of mouth. The earliest of them date back to the days when the written languages of the country were Norman French and low Latin. They helped to preserve the Anglo-Saxon tongue as the main substance of our speech throughout the years when it had been banished from court and monastery alike. Outlawry, therefore, is a frequent theme, occurring in such charming old songs as *The Nut-brown Maid*, with its refrain:

" Therefore I to the wood will go
Alone, a banished man."

Most famous of the outlaws, Robin Hood ruled the Sherwood Forest of Nottinghamshire in defiance of king and sheriff. How far he was real, mythical, or compounded of many woodland heroes, we cannot tell. But his band of lusty rogues, Allan-a-Dale, Friar Tuck, and the fair Maid Marian, are living characters of English literature. Traces of their exploits persist in place names and folk lore of the North and Midlands. Some sixty stories have been recorded. Their popularity arose from their challenge to the Norman domination of English life and language, and in particular to the oppressive

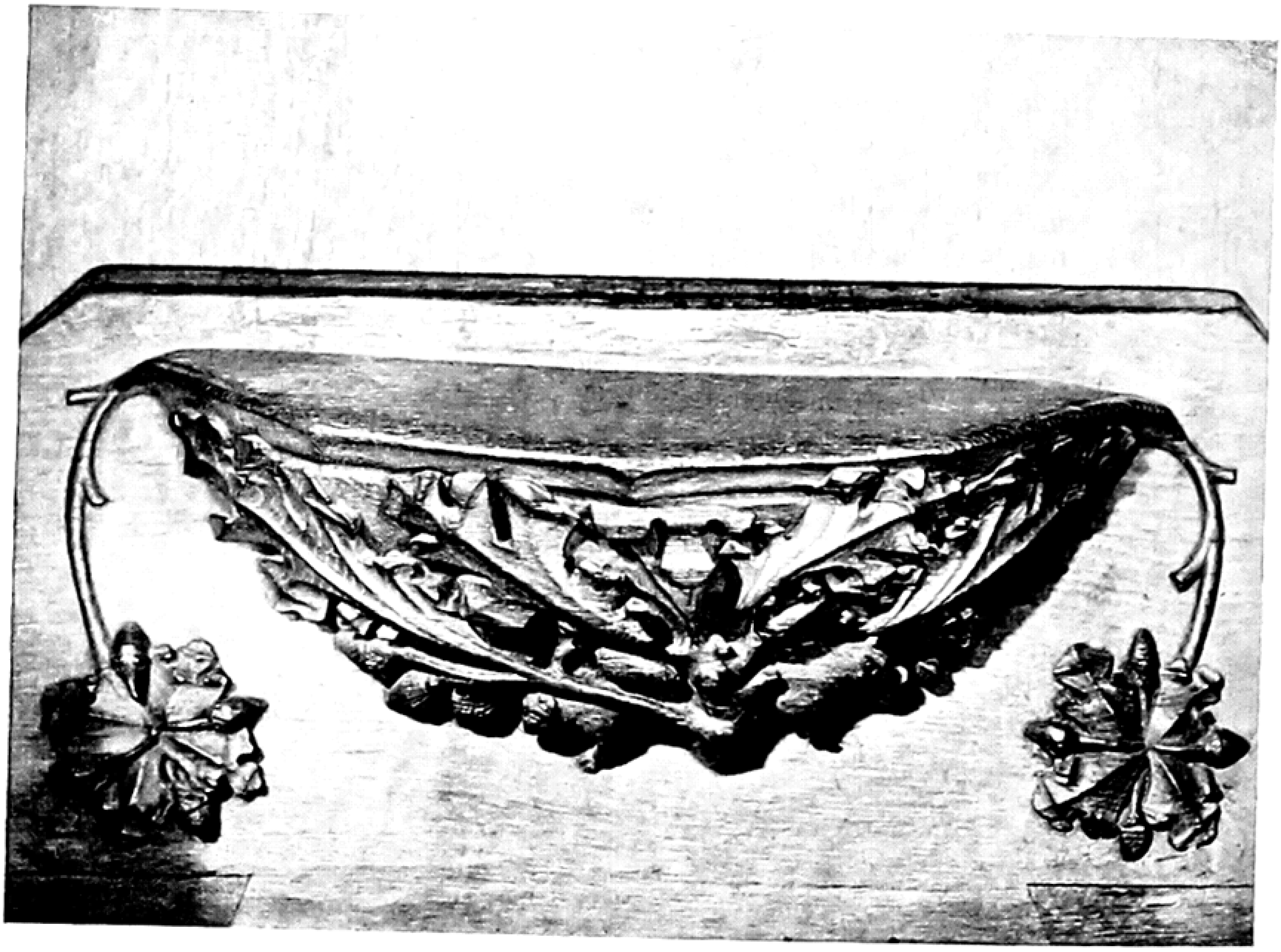


176 BLACK-AND-WHITE WORK IN HEWN TIMBER; THE GATEHOUSE, STOKESAY CASTLE, SHROPSHIRE



177 BUILDING A MODERN LYCH-GATE, WITH ADZE-HEWN ENGLISH OAK, KILBURN, YORKSHIRE

CRAFTSMANSHIP, OLD AND NEW



178 ACORNS, OAK LEAVES, AND WOODLAND BEASTS, CARVED IN ENGLISH OAK AT WHALLEY ABBEY, LANCASHIRE

179 THE DOUBLE HAMMER-BEAM ROOF OF OAK AT KNAPTON CHURCH, NORFOLK

NATIVE OAK IN ENGLAND'S CHURCHES

forest laws. The merry men ranged freely through the greenwood, killing the king's deer at will. Their humbler successors are commemorated by more recent countryside songs, such as the *Lincolnshire Poacher.*

SHAKESPEARE'S WOODLAND COMEDIES

Shakespeare, the Warwickshire countryman, succeeded naturally to the heritage of woodland storytelling. Alone amongst the early dramatists, he takes his audience with him to the woods, with the sure step of the proven forester. In his delightful comedy *As You Like It*, he reveals a first-hand knowledge of woodcraft and deer hunting. Although the characters bear foreign names, the main scene of the play is the Forest of Arden—England's Arden, the wild woods that in Elizabethan days stretched northwards from Stratford-on-Avon. It forms a noble setting for the master playwright's gayest love story.

In even lighter mood, *A Midsummer Night's Dream* takes us to the fairies' realm in "A wood near Athens." But the enchanted wood, when we reach it, proves to be no nearer Athens than Bottom and his crew are to being Athenians. All the imagery is drawn straight from the English countryside, and much of it is so vivid that Shakespeare must be ranked amongst the keenest observers of wild nature.

BORDER BALLADS AND SCOTTISH POETRY

After Tudor times, the background of English literature shifted from the countryside towards the town, but it was otherwise in the North. In the wilder countryside of Scotland and the Borders, song and story alike have maintained close contact with the open-air world. The Border ballads, though they deal tersely with the great elemental facts of life—love, death, and war, contain many apt references to trees and woodlands. The rise of sheep-grazing in more peaceful times has left the Cheviots almost treeless, and these old songs recall a beauty of scenery that has vanished from that land.

Its memory is kept green by such songs as the *Outlaw Murray*, wherein it is said that:

> "Ettrick forest is a fair forest,
> In it grows many a semelie trie,
> The hart, the hynd, the dae, the rae,
> And of a' beasts great plentie."

In the *Ballad of Chevy Chase*, the fight to the death between the doughty champions, Douglas of Scotland and Percy, Earl of Northumberland, follows on the latter's deer-hunting excursion across the Border.

The woodlands of glen and waterside gain constant mention in the writings of Scottish poets. That Burns appreciated their beauty is shown by such songs as the *Birks of Aberfeldy.* In another poem of ponderous title, *The Humble Petition of Bruar Water to the Noble Duke of Atholl*, he pleads for the planting of woodlands to enhance the beauty of a Highland waterfall. His sensitive spirit keenly felt the loss of the Border forests, for in his *Verses on the Destruction of the Woods near Drumlanrig* (which incidentally were felled and sold in order to endow a pretty lady of uncertain parentage), he stigmatizes the then Duke of Queensberry as:

> "The worm that gnaw'd my bonny trees,
> That reptile wears a ducal crown."

The historical novels of Scott did much to recreate for us both the English and Scottish medieval forest scenes. *Ivanhoe* takes us to the English woodlands with their Saxon swineherds and outlaws. *The Lady of the Lake* has as its setting the West Highland woodland, with its wild thickets of birch and thorn, and its shaggy groves of firs, in glens starred by placid lochs below the cloud-capped hills.

RECENT LITERATURE

When English writers returned at length to the countryside for inspiration and a setting to their stories, it was to a land tamed by agriculture and denuded of its great forests. Although recent poetry and prose abound in references to trees and woodland sufficient to fill anthologies, the true forest scene is more suited to historical themes of a remote past. American writers are more fortunate, and the works of Bryant, Longfellow, Thoreau, Robert Frost, and others have revived and sustained interest in the life of the wilds.

Almost alone amongst the moderns, Thomas Hardy, born in the shadow of a great wood hard by Dorchester, recaptures the spirit of the primeval woodlands, fragments of which still persist in his native Dorset. The titles alone of his Wessex novels, such as *The Woodlanders* and *Under the Greenwood Tree*, bespeak this author's interest in the forest, which extended to an accurate knowledge of woodland crafts and industries. In his *Tess of the D'Urbervilles* his description of the wild Cranborne Chase, " the greatest wood in England," gives an unrivalled impression of the mightiness of the everlasting woods, contrasted with the transient dramas of human life.

What may be called the " special " literature of the forest contains as yet few noteworthy books. Writers on natural history in general, such as Gilbert White of Selborne, W. H. Hudson, and particularly Richard Jefferies, turned to the woods in pursuit of the wild life that enchanted them. Though the woods themselves are seldom their main interest, their works could never have been composed in a treeless land.

Noteworthy writers on British forestry are John Evelyn, whose classic work *Silva* has already been mentioned in Chapter 13, Gilpin, Brown, and Nisbet. William Gilpin, Prebendary of Salisbury and Vicar of Boldre in the New Forest, whose *Forest Scenery* was published in 1791, was chiefly concerned with the curious art of Forest Æsthetics. He studied trees, not as timber producers or botanical specimens, but as elements in country scenery.

James Brown, whose encyclopaedic *The Forester*, first published about 1860, became a standard textbook for generations of working foresters, was concerned with practical commercial afforestation, based mainly on Scottish practice. John Nisbet, who edited the later editions of that work, is chiefly known for his translations from German authorities. But his original work, such as *Our Forests and Woodlands* (1900), is based on careful research and observation of British woodland life, and in particular the past histories of English and Scottish forests.

MUSIC

The ballads of olden time, which show how English literature survived for a season (in its earliest Anglo-Saxon form) in the forests of Norman England, indicate also that much of our folk music is of woodland origin. When the harp held sway, song, dance and tune were pastimes of the open air. Those distant days are recalled by the gaiety of the maypole—a tree in origin, and by such old songs as *Summer is acumen in*, which leads the hearer at once to a cuckoo-haunted wood. In later ages, harp, lute, and pipes are seldom heard amidst the medley of less rural strings, and the wood-notes of the hunter's horn are drowned by the roar of less portable wind instruments. But occasionally our composers revert to woodland themes, and the murmuring of the trees has found its way into many modern pastoral pieces.

Religious music also touched upon the life of the forest in medieval times, as in the carol *The Holly and the Ivy*, which opens:

> " The Holly and the Ivy
> When they are both full grown,
> Of all the trees that are in the wood
> The holly bears the crown."

and proceeds to trace a connection between the use of holly berries as a yuletide decoration—probably a pagan survival—and Christ's crucifixion. Its refrain has all the ring of a hunting song:

> " O! The rising of the sun
> And the running of the deer,
> The music of a merry company,
> Sweet singing in the choir,"

and recalls those muscular Christians of a former age, the bishops whom the law allowed to slay the king's deer as they rode across the royal forests.

THE CREATION OF SCENERY

The eighteenth century saw the creation of the great parklands so characteristic of the English scene. Landowners, realising that the true wildwood was vanishing, sought to reconstruct it by planting ornamental grounds in keeping with the romantic spirit of their age (108). Experts, such as " Capability " Brown, were engaged to plan broad landscapes, and the essential media employed in all such schemes were the green English turf and the spreading forest trees. The results, mellowed by time, have come to be numbered amongst the greatest glories of our land. Though naturalism was the aim in view, the parks do not represent true forest conditions. But they give to the trees a new beauty of form due to their widespreading crowns produced by free and open growth. The wildwood provided the material which the landscapist grew to a new perfection; for the first time men grew green trees because they were beautiful.

Although parks are no longer laid out on the grand scale of the eighteenth and nineteenth centuries, their influence survives and affects the texture of open-air life. Some, such as Kew, have become treasure-grounds of rare tree and plant life. Many more have come into public ownership for purposes of recreation. They have had a profound effect on town-planning, pointing the way to tree-lined streets and the more recent " parkways." Their influence on gardening, in country and in suburb, has been great. Trees form the background of the more natural forms of gardening, such as that outlined by Gertrude Jekyll in her classic *Wood and Garden*. The gap between forest and garden is a narrow one, and each has enriched the other. Many common garden flowers, such as daffodils and primulas, flowering and berry-bearing shrubs such as buddleias and cotoneasters, as well as taller flowering trees such as the cherries, have been culled from the woods of our own and other lands.

THE SPORTING SCENE

From pre-historic times, the pursuit of game and the study of the woods have gone hand in hand. But whereas until the end of the Middle Ages the deer and wildfowl ranged through the natural wildwood, in modern times the woodlands have often been artificially created or preserved in order to harbour the game. In particular, the pastimes of fox-hunting and pheasant shooting demand the existence of occasional woods, copses, or coverts, to hold the quarry until it can be driven forth before the sportsmen. In the breeding season the shelter of the woods, together with the food which they provide, are essential for the life of many forms of game, including pheasant, woodcock, wood pigeon, deer, and foxes. Woodland is therefore essential to the lowland game-keeper or game preserver. The possibilities of combining sport with modern forestry have been carefully investigated by competent authorities, who agree that commercial timber crops can be grown with little or no prejudice to game stocks; provided always (and this is an absolute essential) that the rabbit is not numbered amongst the animals to be preserved and encouraged.

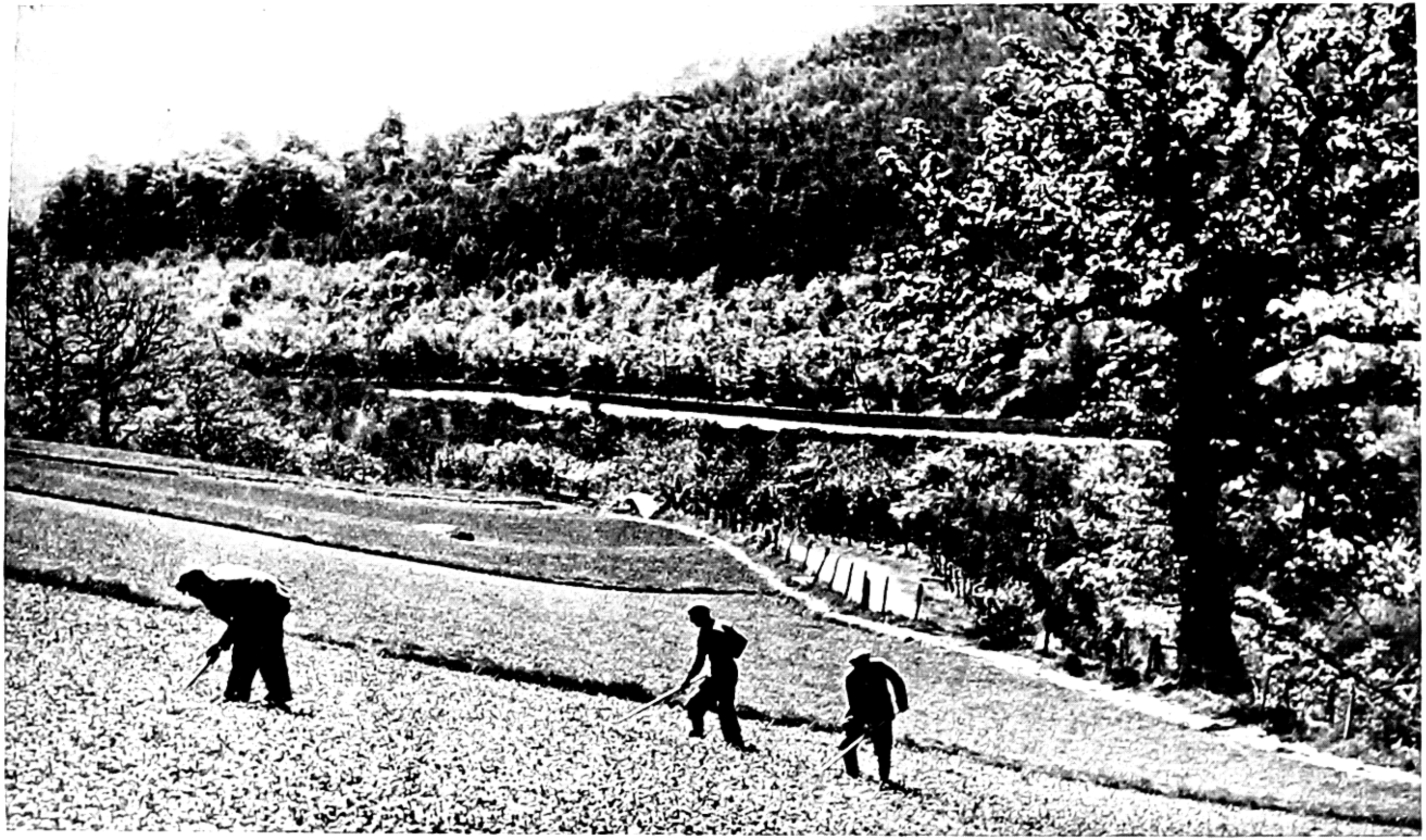
FORESTS AND SEA POWER

In another and most vital respect the forests of Britain influenced the structure of her national life. They enabled her to build, and maintain upon the high seas of the world, a fleet that shattered the might of Spain, carried her trade and colonists to the farthest corners of the earth, and wrought the downfall of the great Napoleonic empire. The oak of the New Forest and the Forest of Dean, shaped and hewn with rare skill by the shipwrights of the Solent and the Severn, gave the strength required to stand the strain of the seas and the shock of combat. Naval architecture developed with timber as its basic material, and when at length the wooden hulls gave way to steel, and the forest shipyards disappeared, the old skill remained, and with it the navy and its influence on recent history.

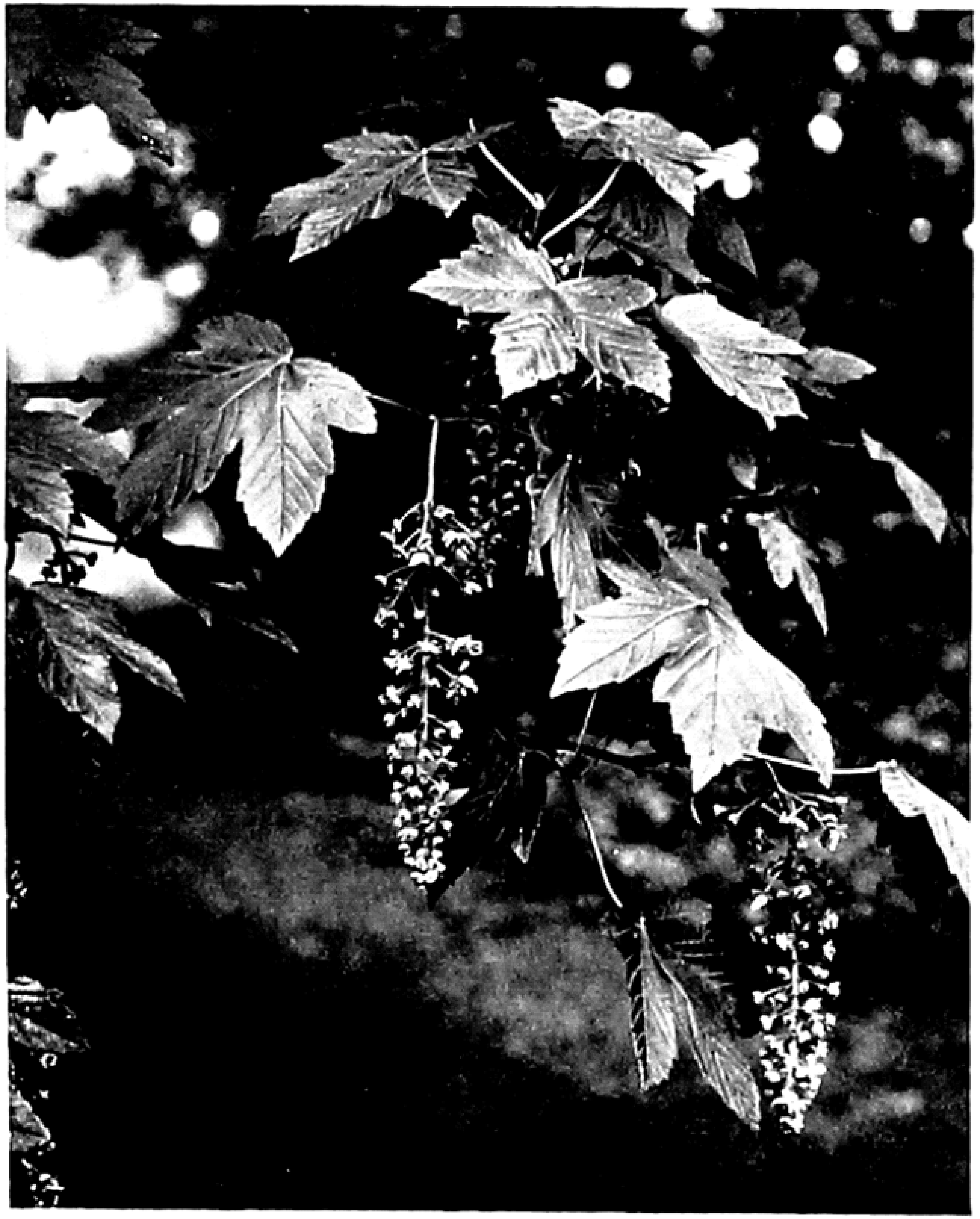
FORESTS AND ARCHITECTURE

The peculiar character of any local style of architecture is governed, above all else, by the nature of the building materials found in each district. Styles of permanent building that use our native timber as their staple material are now rare in Britain, for that commodity has become, for the time being at least, too scarce for such usage. But in prehistoric and in early historic times, domestic buildings were framed with hewn timber in all the forested districts of England, unless indeed some more primitive hutwork of branchwood, or wattle-and-daub, sufficed to keep out the elements. Sawn timberwork was beyond the resources of early man, who could not devise the large pitsaws required for its tedious preparation by hand labour. Stone was only used, in those parts where it is scarce (such as much of the south-east of England), for forts or castles, temples or churches, which have naturally outlasted the more perishable dwellings of timber.

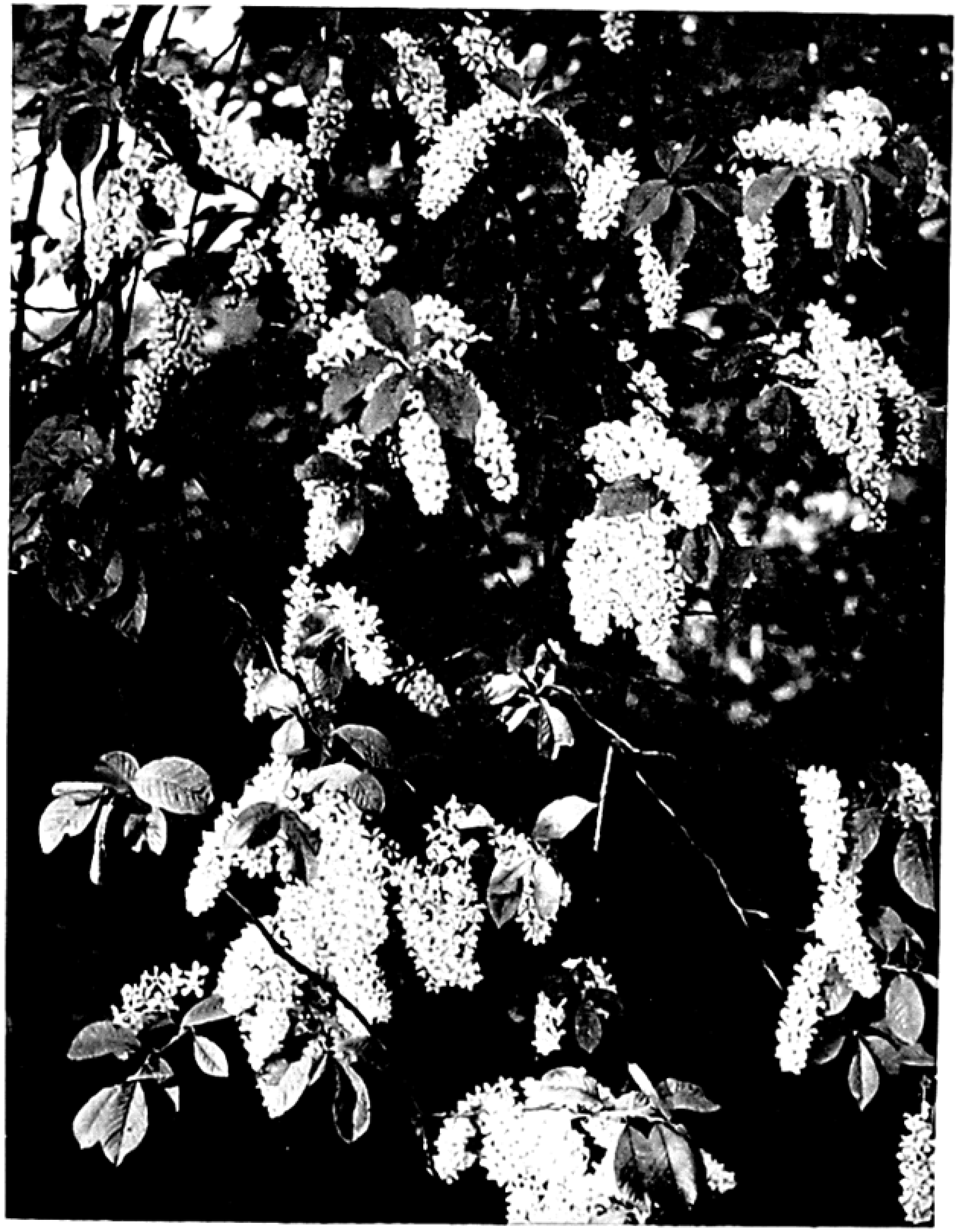
Some of our oldest domestic buildings are of the " half-timbered " form, typified by the " black-and-white " halls of Cheshire and the Welsh Marches. This method of construction uses *hewn* timber, usually oak, as a structural component of great strength and durability, whilst the walls within the wooden frame are composed of various mineral materials,—brick, cob, or wattle-and-



180 A FOREST NURSERY AT BETTWS-Y-COED, SNOWDONIA NATIONAL FOREST PARK, CAERNARVONSHIRE



181 FLOWERS AND FOLIAGE OF SYCAMORE



182 BIRD-CHERRY BLOSSOM

daub. Its use increased with the advance of building technique, and the growing scarcity of timber in the latter part of the Middle Ages (176, 177).

Other signs of the importance of England's forests to her native architecture are to be found in the overhanging upper storeys of old town houses, a design peculiarly adapted to timbered construction; and in the roofwork of great cathedrals and public buildings, such as Westminster Hall. (179). Within the house itself, the oakwoods made their contribution to design and decoration in bare beams or fine panelling, and interior timberwork forms one of the peculiar attractions of our old country houses. In stern contrast, the Scots castles in the Baronial style rely instead upon their native stone; but they, too, embody in their structure the timber of their country,—the strong, resinous, durable red deal from the indigenous Scots pine.

The importance of wood as an ancillary to stone should not be overlooked. Even the simple stone-walled and heather-thatched houses of the Hebrides require a wooden roof-tree, and the lofty vaulted roofs of our medieval cathedrals were formed upon templates of timber, long since removed and seldom remembered.

FURNITURE FROM BRITAIN'S FORESTS

The woodlands have also influenced the development of domestic life by providing raw material for furniture. During certain periods the masters of British cabinet-making resorted to rare imported timbers, but humbler craftsmen were faithful to their native oak. This most useful and adaptable of timbers recorded their skill in durable form, and their handiwork is now prized and sought after by the collector. Although the oak now used for furniture making is frequently of foreign origin (for such works more easily), our woods still provide considerable quantities of beech and elm for use in chair making.

In the embellishment of indoor furnishings, native timbers have provided a worthy medium for the craft of the wood-carver. The choir stalls of cathedrals perpetuate the artistic ability of unknown artisans, and preserve some token of the spirit of medieval life. Here again the material used is usually the durable oak, which when seasoned preserves its original shape, after carving, to a remarkable degree (178). Other woods employed by modern wood-carvers for artistic work and sculpture are lime (used by Grinling Gibbons), beech, pear, and sycamore.

THE ARTIST AMIDST THE TREES

Trees, as an essential ingredient of the countryside scene, have found their due place in our landscape painting. One must say trees, rather than forests, for it is the isolated trees of the farmlands and the riverside that have shown themselves best adapted to the painter's technique. In particular the trees of East Anglia have been immortalised by the work of the Norfolk school. Crome painted trees with a sympathetic understanding of their varied form and growth. Constable's trees reflect every phase of sunlight and wind playing upon their foliage, yet remain true to their kind as regards the elements of their branching and general structure.

The careful work of these artists, who realised that every kind of tree has its own pattern of growth, that each individual tree grows on its own plan as governed by its surroundings, and that these singularities form but the groundwork for the play of the weather and the changes of the seasons, is sharply contrasted by the formal, stereotyped, tree-painting of others. Even Gainsborough was a notable backslider in this respect. In his youth he produced a masterpiece, the *Wood Scene, Cornard, Suffolk*, depicting faithfully the natural structure of oaks in an oakwood. Later on he filled his canvasses with mysterious trees of no recognisable species, intended purely as a background to his brilliant portraits.

The technical study of tree form, from the artist's point of view, has been greatly advanced by Rex Vicat Cole in his *Artistic Anatomy of Trees*, and also by the writings of Hamerton. But within the limited field of illustration, pure and simple, no master hand has yet arisen. One may search in vain for any series of tree portraits, as contrasted with competent technical drawings. The scale of the growing tree, containing so much fine detail of leaf and bud, bark and bough, flower and fruit, and itself but a detail in the surrounding forest, makes it infinitely more difficult to delineate than, for example, a bird, whose form is defined in size, though intricate in shape and colouring.

TREE PHOTOGRAPHY

Trees present a camera subject of the widest scope. Here and there, even in Britain, they clothe vast landscapes. Elsewhere the full-sized tree claims attention with its beauty of form, either alone, in groups, or as a graceful foil to some broader landscape scene. Then the finer detail of buds, leaves, blossom, and fruit, has its own particular range of interest and delicacy of form. The forester calls for views of a technical rather than a picturesque quality, whilst the microscopic structure of leaf cells and wood sections forms another specialised field of tree photography. Even aerial photography is of assistance to the forester, for maps that show the state of his tree crops can be obtained from an aerial survey more rapidly than by doing the field work at ground level (170).

The foliage of trees is well adapted to a form of art in which light is the active element, for the leaves themselves are designed to utilise light in various ways, and to absorb, reflect, or transmit it to varying degrees. Thus the young leaves of the beech are translucent, the older leaves opaque; whilst the crown of the beech casts a far heavier shade than that of a light-demanding tree such as an oak or ash. The outline of a tree can be recorded by its obstruction, as well as by its reflection, of the light from the sky, giving striking silhouette effects. Forests afford a fruitful field for this new form of graphic art, but only the motion picture can recapture their constantly stirring life, sensitive to every whim of the wind.

The forest has long ceased to be a dominating feature of the British countryside, but its influence on our literature, our painting, and our constructional skill, has been too profound to be ignored. As new forests arise to replace the losses of the wars, and as the remnants of the wildwood are preserved and renewed with increasing care, our storytellers and artists may look again for inspiration beneath the trees, whilst our craftsmen discover new skills in the design and moulding of their timbers.

CHAPTER 24

THE FOREST SCENE

Though the forests of Britain have been curbed and tamed by mankind, much of their wild natural beauty remains. Every grove or wood, whether it springs from natural sources or arises as the result of man's handiwork, is a community of living trees growing intimately together. Each tree of the group lives in a delicate state of balance between primeval forces. Battling against wind and weather, it arises as a seedling, then a sapling, from the minute seed that gave it birth. Enduring assaults by animals, birds, insects, and the more insidious foes of the plant world—choking weeds, climbers, and fungal diseases, it builds up its graceful form until it dominates and overtops all forms of life dwelling within its shades.

It is only within recent centuries that man has learnt to control the forest for his own ends. He knew it first as a hunter, seeking his prey in its trackless wastes. Then as a farmer, felling clearings to exploit its fertile soil. As his civilization grew and developed, he drew on it more and more as a source of raw material. At first it seemed inexhaustible. Now it is dwindling. Happily he has studied the way to re-create its fruitfulness. From the tiny seeds of the doomed forest giants he raises anew the tender young trees, and arrays them in their thousands on the bare waste lands. Looking beyond his own lifetime, he tends them with care for the benefit of the generation that shall succeed his own, a priceless endowment for posterity. He plans the work so that nature assists him, and his labours are repaid with the fine timber that he shapes to meet his manifold needs.

As this work goes forward, new beauties of foliage appear to ornament the scene, replacing the older ones that vanish as their hour falls due. For the true forester, though he must fell trees for timber, will never destroy his forest. Always he aims to replenish the devastated woods with younger, fresher, trees, growing for the use of another generation, forming a further range of soft-hued leaf and delicate tracery of stem. The forest changes, but endures. A hundred years hence it will be as attractive as it is to-day.

Our forests have been studied with a view to their preservation and perpetuation, and also as a sublime example of the working of biological forces. But much of their mystery and beauty lies unrecorded alike by forester and scientist. Only the artist's brush and the pen of the poet have been swift and sure enough to catch and hold the ephemeral beauties of the British woodland scene.

Our spring is heralded by the snow-white blossom of the blackthorn, succeeded by the rosy haze of tiny florets on the high elms. Not every tree flowers in spring, but all put forth new leaves—the emerald of the hawthorn, the intenser, paler green of the larch, the filmy beech, and the robust chestnut. The cone-bearing trees, too, clothe their evergreen forms in a fresh mantle of needles, sending up aspiring shoots of spruce and fir, clad with a multitude of narrow leaflets, odorous with the scent of resin.

Much of this green canopy is overlaid by a later coverlet of blossom. There comes the snowy cloud of crab apple, with pear, whitebeam, and cherry; the opulent horse chestnut, and the strange green flowers of oak and beech. The pines are golden with their pollen, and the larches bear quaint and delicate rose-red cones.

The green majesty of the summer leaf is followed by the glory of autumn. A rich mingling of browns, russet-reds, and golden yellows, varying from tree to tree and branch to branch, heralds the fall of the foliage. It is heightened by the ripening fruits, yellow crab-apples, scarlet rowan berries, brown chestnuts, rosy yewberries, and quaintly shaped grey-brown cones.

The fall of the fading leaves lays bare the intricate tracery of the branches that bore them so bravely aloft to catch the light of the sun. Now each tree reveals its structure—sturdy ash, rambling oak, sinuous beech, dainty birch, and feathery larch. Only the conifers stand sombrely in their evergreen dress, silently awaiting the call of another spring. To the boughs or enduring leaves of winter, frost and snow lend an enchanted, glistening whiteness. Mighty branches of fir and spruce gather great loads of gleaming crystal snow, whilst hoar frost outlines the symmetry of fallen leaves and leafless twigs.

Each of our many kinds of forest tree has its recurring rhythm of beauty as the seasons wax and wane.

Even the passing of a single day brings to the woodlands a succession of changing moods. In the still dawn, the forms of the great trees slowly assume their varied shapes as the light increases and the mists dissolve. Mid-day brings out their varied hues of green as the stronger sunlight plays down upon them. The setting sun of evening strikes from a new angle to illumine bark and branches. Markedly vivid is the warm rosy hue of the Scots pine stems, enhanced by the reddening sunset. Then twilight, and the giant forms sink beneath the concealing cloak of night, or catch the silvery glitter of the amber moon.

The winds lend to the tall trees their poetry of motion. Each tree has framed its trunk, branches, and foliage, to withstand the thrust and pull of the gales by swaying in a particular fashion. Rigid-boled trees, such as oak and beech, leave all the play to their branches, but the tall pines and slender larches, and saplings of all kinds, allow their supple trunks to sway freely. Sometimes the whole crown of the tree moves, sometimes only the limbs swing to and fro at the wild wind's call. In the aspen and other poplars the quivering motion of the leaves is all but incessant. The whole tree scintillates as new facets reflect the sun.

Nor are the trees silent. The wind strikes chords upon their straining leaves and frail meshwork of twigs, as upon a vast harp. The rustling of their great crowns is overborne in times of stress by the creaks and groans of the stouter branches wrestling with the gale.

The woodlands have their own range of sweet scents and fragrances. Each of the conifers exhales an odorous resin that perfumes the air, rich and full-bodied in the pines, acrid in the thuyas, delicious in the bark-blisters of the Douglas fir. But some of the broadleaved trees outvie them, for there is no fragrance more delightful than that from the gummy buds of the balsam poplars on a fresh spring day, whilst bruised walnut leaves give forth a fine savoury odour. Then there is the earthy tang of soft mould on the forest floor, and the smell of blue wood-smoke flavoured by the timber whence it arose, the conifers yielding their resinous essences and apple-wood the taste of its ripened fruit.

In hilly country the woods mask the contours with a soft rich covering of green, whilst solitary trees stand out as bold sentinels on the peaks and ridges. They break the bareness of the uplands, giving shelter to man and beast. But it is by the waterside that the woodlands display their grace to greatest advantage. In the shelter of the dale, with a cooling draught of water at their roots, and basking in the full light striking across lake or river, trees attain great stature and a shapely form which is repeated in their liquid reflection. Their shade seems deeper and more welcome there, for their shadows contrast with the glare of light upon the water.

Away from the wilds, trees retain their attractiveness in parklands, farms, and even in the city streets, whither they are followed by the birds that haunt the woodlands. But though they play an essential part in the rural scene and in relieving the tedium of endless buildings, they lack the freedom of their fellows in the wildwood. Nevertheless they help to recall the charm of the far hillside groves, where the sunlight filters through a canopy of waving green to light upon the mossy forest mould, and the cool winds wander at will to the music of babbling brooks fed with sweet water from deep springs. There the great giants of the forest feel the pulse of the seasons, and respond with upsurging growth, whilst the deer browse beneath them, and the buzzards circling round their eyrie in the treetops give their plaintive call.

By working with the forces of nature, man can create afresh the beauties of the forest realm; but it is not easy, and it may take a lifetime. At first his trees are puny things, all of an age and a size. They have no taller stalwarts to shade or shelter them, and must struggle up slowly together. After a few years, however, their spreading branches meet and interlace, and, as if gaining heart from this companionship, they forge rapidly ahead. Behind them lie the days when they fought for light, air, and the goodness of the soil with a host of lesser herbs. Now they have mastered the field, and the only competition is amongst themselves. Next the axe of the forester improves on the natural course of growth, for he culls out all the rough misshapen stems, leaving only the straightest shafts to ascend and enlarge as timber. The plantation becomes an orderly array of the finest trees, alike in age, size, and general shape. But each tree has a singularity, almost a personality, that is appreciated by the forester who tends it, the axe-man who fells it, and the sawyer who at length lays bare its heart.

No two trees, no two sticks of timber, are alike. Each has its variations on the pattern of its kind, recorded in the growth of its wood. The favoured tree that grows in full light forms wider rings in its timber, of a coarser grain than that of its own brother, hampered by too much shade. Yet an adverse season is shown to some degree in the wood of all the trees of a district, by diminished growth during that year. Even the branches of the crown are disposed differently from tree to tree.

The link between man and tree is a close one. The plants of field crops are sown and reaped by the thousand, handled by machinery throughout; they endure a few months, are harvested, and forgotten. But trees must be planted separately one by one, weeded and pruned individually, and considered each on its merits when thinnings are made. They are felled, each in turn, by hand, and the sawyer at the mill converts each trunk in a different way. Although the forester may at times use machinery, to prepare the ground for planting or to haul out timber, the intimate touch of " green hands " is required for the growth of every planted tree. And trees endure for so long that one comes to know them, almost as friends.

The calling of the woodman demands strength, skill, keen observation, and a deep understanding of wild nature. There is need for muscular power, allied to an ability to sense how man's hands may be used to advantage in the difficult tasks of felling a tree or causing one to grow. Dangers there are, too, for no tree falls without some degree of risk to those near it; but the woodman develops great self-reliance. Working always out of doors, at points scattered over a wide stretch of lonely woodland, he finds constant variety in his work, and a sense of freedom. His tools, the ringing axe and the singing saw, call for grace of movement and the employment of all the muscles and sinews of the human frame. By the strength of his arm alone is the wide woodland controlled to yield its wealth of timber.

Forests preserve many features of wild life that might otherwise be lost. They have saved our few remaining large mammals, deer and badger, wild cat, pine marten and polecat, from extinction in their truly wild state. Their value to bird life is difficult to over-estimate, for they provide cover from enemies, shelter in winter, and an abundance of suitable nesting sites. Not only do they form the haunt of true woodland birds such as the woodpecker, the jay, the crossbill, and the gold-crested wren, but they help the birds of field and garden to maintain their numbers. Rare plants also persist in the depths of the forest, long after the plough has driven them from the tilled fields.

There is more in the forest than an assembly of trees that shall one day become timber. The trees triumphant, growing and changing in harmony with the weather and the seasons, are themselves a splendour. Following them there comes a host of lesser delights—delicate plants of the wildwood, rare birds and shy beasts, a carpet of strewn leaves, and a dappled shade.

Not only are the woods a source of livelihood to sturdy woodmen, and a resort of study for the naturalist, but they are a solace to the town-dweller, and the home of interwoven beauties of form, colour, movement, perfume, and sound that may enrich the lives of all.

For these reasons, above all, the British forests are cherished as a heritage. Wood is used here as elsewhere, and the skill to grow and handle it is as essential as it is abroad. But our woods will never be regarded as mere timber factories. They are part of our land, intermeshed with the countryside like threads in the web of its carpet of living green. Let us leave the last words with Keats,—

> " Happy is England! I should be content
> To know no other beauties than her own,
> To feel no other breezes than are blown
> Through her tall woods with high romances blent."

GLOSSARY

The technical terms, weights, and measures listed below are all in frequent use, and many of them have meanings in forestry that differ from their implications elsewhere. Certain of them have two or more meanings even in forestry practice alone, and few are satisfactorily defined by the average dictionary. As a general rule, words, weights, and measures that are already fully defined in the text are *omitted* from the glossary, and should be sought in the index.

ACRE. 4,840 square yards, or 10 square chains. 640 acres equal 1 square mile.

ANNUAL RING. The circular zone of timber formed by each year's growth of a tree's trunk or branch.

ARTIFICIAL REGENERATION. The replacement of a tree crop by planting or sowing.

BAULK. A large piece of squared timber.

BEATING-UP. Replacing failed trees in a plantation.

BLAZE. A mark made on a tree trunk by slicing off bark.

BOARD FOOT. The customary unit of measure for timber in North America, equal to one-twelfth of a true cubic foot.

BRASH. Remove side branches from young trees, or material so removed.

BREAST HEIGHT. The standard height for measuring the girth of a standing tree, usually taken as 4 ft. 3 ins. above ground level.

BROADLEAF, BROADLEAVED TREE. A tree of the natural order *Dicotyledones*, distinguished by the seeds, each with two cotyledons, being enclosed in fruiting bodies or " fruits."

BRUSH UP. See " Brash."

BURY (noun). A place where young trees are heeled-in or sheughed-in.

BUTT. The larger or basal end of a tree trunk or log.

CANT. An area of variable extent on which coppice is cut, or grows at an even age.

CANT-HOOK. A tool for turning or rolling logs.

CHAIN. 22 yards, or a measuring chain of that length.

CLEANING. Removing tree weeds and woody climbers from a young plantation.

COLLAR. That part of a tree that lies at or about ground level.

COMPARTMENT. An area of variable extent, forming a unit for forest management purposes.

CONIFER. A tree of the natural order *Coniferae*, distinguished by seeds borne unenclosed on the scales of cones.

CONVERT. (1) Change timber from its natural state to a manufactured form, e.g. logs into sawn boards.
(2) Change an area of woodland from one form of tree crop to another, e.g. coppice to High Forest.

COPPICE. Cut back trees to their base so that they will shoot again; the process of shooting again; or an area of woodland so treated. (See Chapter 13.)

COPPICE-WITH-STANDARDS. See Chapter 13.

CORD. A measure of capacity for stacked branchwood. 128 cubic feet, usually measured as 4 ft. × 4 ft. × 8 ft.

COTYLEDON. The first seed-leaf of a seedling plant or tree.

CROWN. The upper branches and foliage of a tree.

CUBIC FOOT. The basic unit for measuring the volume of timber. See Chapter 20.

CULL. An unsuitable, undersized, or rejected tree.

DECIDUOUS. Losing all its leaves during a portion of the year, normally in winter.

EVEN-AGED WOODS. Woods in which all the trees are of more or less the same age.

EVERGREEN. Retaining a portion of its leaves throughout the year.

FATHOM. A measure of capacity for rough sawn timber, 216 cubic feet, measured as 6 ft. × 6 ft. × 6 ft.

FINAL CROP. That portion of a stand of trees that is felled at the end of a rotation.

FOOT RUN. A unit for measuring squared timber. When breadth and thickness are known, quantities may be stated in feet of length, or foot-run.

FOOT SUPER. A unit for measuring squared timber or plywood. When thickness is known, quantities may be stated in square feet of surface area, or foot super.

FURNISHED. Equipped with side branches or foliage.

GIRTH OR GIRT. The circumference of a tree or log; the point of measurement should be stated, as logs normally taper.

GREEN CROP. A crop of soft green annual plants, such as mustard or lupin, that is ploughed into the ground in a green state, to improve soil fertility.

HARDWOOD. A broadleaved tree; or the wood derived therefrom.

HEEL-IN. To bury the roots of young trees below ground, to keep them moist and free from frost whilst awaiting planting.

HIGH FOREST. See Chapter 13.

HOPPUS FOOT. See Chapter 20.

HUMUS. Organic matter, consisting of plant or animal remains, in the soil.

KERF. The gap cut in timber by a saw blade.

LEADER. The main upright shoot at the top of a growing tree.

LINING. Spacing young trees in lines when planting them in the forest.

LINING-OUT. Transplanting young trees into straight lines in the forest nursery.

LOAD. 50 true cubic feet of timber.

MAST. The seed of trees, particularly oak and beech.

MATURE. Full grown and ready for cutting, normally at the end of a rotation.

MIXED CROP OR MIXTURE. Composed of more than one kind of tree.

MOTHER TREE. A tree left to bear seed for natural regeneration.

MYCORRHIZA. A composite structure, consisting of tree roots and fungal threads.

NATURAL REGENERATION. The replacement of a tree crop by natural seedlings or sucker shoots, without planting or sowing.

NORMAL. See Chapter 21.

NURSE. To shelter a young tree; a tree grown to shelter others.

ONE-YEAR-ONE or ONE-PLUS-ONE. A transplant that has grown for one year as a seedling, and for one further year as a transplant. So "Two-plus-one," etc.

PAN. A hard impervious layer below the surface of the soil.

PEAVY. A tool for turning or rolling logs.

PEEL. (1) Remove bark.
(2) Remove a layer of veneer. (See Chapter 18.)

PERCH. A unit of area, 30¼ square yards. 16 perches equal 1 square chain. 160 perches equal one acre. (Strictly, a "square perch.")

PILE. A fence-stake. (Hampshire).

PLANTATION. A crop of trees artificially planted or sown.

POLE. (1) A unit of area, equal to a "perch." (Strictly, a "square pole").
(2) A slender woody stem or tree, usually too small to yield sawmill timber.

POLE CROP. A crop of young trees at the stage when they resemble or consist of poles.

POLLARD. Cut back a tree at a few feet above ground level, so that it will shoot again; or a tree so treated.

PURE CROP. A crop consisting of only one kind of tree.

QUARTER. The radius of a tree trunk. Cut on the radius.

QUARTER-GIRTH. One-fourth part of the girth or circumference of a log or tree.

QUARTERING. Sawn timber more or less square in cross-section.

RACK. A narrow pathway cut through growing trees. (Fig. 135.)

RAILWAY MEASURE. For carriage by rail, the weight of timber is usually estimated by allowing so many cubic feet to count as one ton, on a standardized schedule, varying with species.

RIDE. A wide track running through a forest. (Fig. 134.)

ROD. A unit of area equal to a perch. (Strictly a "square rod.")

ROOD. A unit of area, equal to 40 (square) perches, or 2½ square chains. 1,210 square yards. 4 roods equal one acre.

ROTATION. The period between cutting successive crops of timber trees or coppice on the same piece of ground; or, the age to which the main crop of timber or coppice is grown before cutting.

SAPLING. Any young tree.

SCRIBE. A cutting tool used for marking trees or timber.

SEEDLING. Any tree grown from seed without transplanting, particularly a young tree in a forest nursery.

SELECTION WOODS. See Chapter 13. In selection woods, the rotation is the age to which the largest trees are normally permitted to grow before cutting, as the whole wood is never cut down.

SHEUGH-IN. (Scots.) See "Heel-in."

SLAB. Irregular section of timber and bark cut from a log when squaring it.

SLIPE. (Scots.) Draw timber, trees, or materials on a sledge.

SNED. Cut away side branches, particularly from a felled tree.

SOFTWOOD. A coniferous tree; or the wood derived therefrom.

SQUARE. (1) Multiply any given number by itself. (Chapter 20.)
(2) Convert a round log to a square or nearly square cross-section. (Chapter 18.)

(3) A unit of measurement for sawn timber, enough to cover 100 square feet. The thickness must be stated, and it is usual to state the width of the individual pieces also; the length of each separate piece is normally a variable factor.

SQUARE CHAIN. Unit of area for land. 22 yards × 22 yards. 484 square yards. 16 (square) perches. 10 square chains equal 1 acre.

SQUARE YARD. Unit of area, one yard (or 3 feet) square.
30¼ square yards equal 1 (square) perch.
484 square yards equal 1 square chain.
1,210 square yards equal 1 rood.
4,840 square yards equal 1 acre.

STANDARD. (1) The customary unit for measuring imported sawn timber, containing 165 cubic feet, of any specification.
(2) A large tree grown in a coppice crop. (Chapter 13.)

STOB. A fence stake. (Scots, Gaelic derivation.)

STOOL. The base or stump of a coppiced tree.

STORE. To leave young trees uncut in a coppice crop; or a tree so left.

SUCKER. A young tree arising from the roots of an older one.

SUPPLYING. See "Beating-up."

THIN. Remove certain selected young trees to benefit the remainder of a crop.

THOUSAND. One thousand board feet, equal to 83⅓ cubic feet, or about half a standard (North America).

TON. Statistics of timber imports are given in "Import tons" of 50 true cubic feet *volumetric* measure.

TRANSPLANT. To move a living tree from one growing point to another; or a tree so treated.

TRUE MEASURE. The actual volumetric measure of a tree or log. See Chapter 20.

TURN. To convert timber by spinning it on a lathe against cutting tools.

TUSH. To draw timber over the ground, without using a carriage.

UNEVEN-AGED WOODS. Woods containing trees of various ages growing together.

VIRGIN FOREST. Natural woodland uninfluenced by man's activities.

WANE. The irregular surface sometimes left on the edges of squared timber.

WEED. A plant or tree growing where it is not wanted.

WOLF TREE. A misshapen tree that outgrows and suppresses its neighbours.

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